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PSYCHOLOGICAL AND EDUCATIONAL FACTORS IN TRANSFER OF TRAINING, PHASE I. LEARNING HOW TO LEARN UNDER SEVERAL CUE CONDITIONS. TECHNICAL REPORT I.

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DESCRIPTORS- LEARNING PROCESSES, *TRANSFER OF TRAINING, PSYCHOEDUCATIONAL PROCESSES, *TASK PERFORMANCE, *PROBLEM SOLVING, *PROMPTING, *RESPONSE MODE, TESTS OF SIGNIFICANCE,

THE OBJECTIVES OF THIS STUDY WERE (1) TO IDENTIFY AND COMPARE THREE KINDS OF TRANSFER EFFECTS--AN EFFECT ASSOCIATED WITH CUE REPETITION, A LEARNING-TO-LEARN EFFECT, AND A WARM-UP EFFECT, AND (2) TO EVALUATE THE USEFULNESS OF CUE-RESPONSE CORRELATIONS IN EXPLAINING TRANSFER EFFECTS. THE STUDY WAS BASED ON THE DEFINITION OF TRANSFER EFFECTS AS CHANGES IN ABILITY TO DEAL WITH SITUATIONS NOT ENCOUNTERED DURING TRAINING. SUBJECTS WERE UNDERGRADUATE COLLEGE STUDENTS WHO WERE DIVIDED INTO SIX GROUPS. FOR HALF OF THE SAMPLE, THE TRAINING AND CRITERIA TASKS WERE SIMILAR. FOR THE OTHER HALF, THE TRAINING AND CRITERIA TASKS WERE QUITE DIFFERENT. FOR ONE GROUP FROM EACH HALF OF THE SAMPLE, THE RELEVANT AND IRRELEVANT CUES REMAINED THE SAME FOR ALL TASKS. FOR THE SECOND GROUP FROM EACH HALF, THE RELEVANT AND IRRELEVANT CUES WERE REVERSED ON THE CRITERION TASK. FOR THE REMAINING GROUPS, COMPLETELY NEW CUES WERE INTRODUCED DURING THE CRITERION TASK. A CONTROL GROUP PERFORMED ONLY THE CRITERION TASK. THE ENTIRE EXPERIMENT WAS CARRIED OUT TWICE, ONCE USING LARGE GROUP TESTING PROCEDURES AND ONCE WITH GROUPS OF EITHER SEVEN OR 14 AT A TIME. ERROR SCORES WERE USED AS A MEASURE OF RATE OF LEARNING. THE INVESTIGATOR ATTRIBUTED THE GREATEST TRANSFER EFFECT TO WARM-UP, AND THE NEXT LARGEST TO LEARNING-TO-LEARN EFFECTS. NO SIGNIFICANT EFFECT WAS FOUND FOR CUE REPETITION. SINGLE-TRIAL, CUE-RESPONSE CORRELATIONS (CRITERIALITIES) PROVED USEFUL IN INTERPRETING THE TEST RESULTS. THEY ALSO DEMONSTRATED THE PRESENCE OF CUE-SIMILARITY EFFECTS NOT DETECTABLE IN THE ERROR SCORES. (AL)

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## LEARNING HOW TO LEARN UNDER SEVERAL CUE CONDITIONS

DALE E. MATTSON

TECHNICAL REPORT NO. 1
AUGUST, 1963

PSYCHOLOGICAL AND EDUCATIONAL FACTORS IN
TRANSFER OF TRAINING
Phase I

U. S. OFFICE OF EDUCATION
Contract 2-20-003

Lawrence M. Stolurow
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# Learning How to Learn Under Several Cue Conditions[1]

Dale E. Mattson

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LEARNING HOW TO LEARN UNDER SEVERAL CUE CONDITIONS

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Department of Education

University of Illinois, 1963

The first objective of this experimental study was to identify and compare three kinds of transfer effects: an effect associated with cue repetition, a learning-to-learn effect, and a warm-up effect. The second major objective was to evaluate the usefulness of cue-response criterialities in explaining transfer effects.

A factorial design was employed with three degrees of similarity between the relevant cues for the training tasks and those for the criterion task and two degrees of similarity between type of training task and criterion task.

Conditions of Cue Similarity. For one third of the experimental Ss relevant and irrelevant cues remained the same for all tasks; for another third relevant and irrelevant cues were reversed on the criterion task; and for the remaining third completely new cues were introduced during the criterion task.

Conditions of Task Similarity. For half of the experimental Ss training and criterion tasks were of the same type. For the other half training tasks and criterion tasks were quite different.

In addition to the six experimental groups necessary for the experimental design an additional group of Ss was a control group who performed only the criterion task.

The entire experiment was carried out twice--once using large group testing procedures and once testing groups of either 7 or 14 at a time.

The Ss for this experiment were undergraduate college students. For the first experiment in which large group testing procedures were used the Ss participated in the experiment as part of a course requirement either in introductory psychology or in educational psychology. For the second experiment all Ss volunteered.

The results of the study may be summarized as follows:

1. Ss of the three cue conditions did not differ significantly on the number of errors made during the completition of the criterion task.

2. A learning-to-learn effect was identified. Ss who received training on a series of training tasks similar to the criterion task completed the criterion task with fewer errors than Ss for whom training tasks were unlike the criterion task.

3. A warm-up effect was identified. Subjects who performed a series of four tasks quite different from the criterion task, using cues unlike those used on the criterion task, completed the criterion task with fewer errors than Ss in the control group.

4. Using the same two cues in the solution of a number of training tasks increased the use of these cues on the first trial of the criterion task. The criterialities (correlations between cues and responses) were higher on the first trial of the criterion task for cues that had previously been relevant than for cues that had been irrelevant.

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# CHAPTER I

## INTRODUCTION

Transfer effects may be defined as changes in ability to deal with situations not encountered during training (Cronbach, 1963). The range of conditions that lead to transfer may be illustrated by studies of the learning of lists of paired-associates. In an early experiment Bruce (1933) studied the transfer resulting under several conditions of similarity between training lists and the criterion list. The greatest positive transfer occurred when the response terms were identical for training lists and the criterion list. However, positive transfer also occurred when the lists used for training were completely different from the criterion list. In a more recent study Thune (1950) demonstrated that color guessing had a facilitating effect on the subsequent learning of a list of paired-associates.

As we consider these examples in turn, the similarity between training task and the criterion task becomes progressively smaller. For Bruce's first condition the similarity between the training task and the criterion task is evident. For his second condition the similarity is much less obvious; only the requirements of the training tasks and the criterion task are the same. Finally, it is difficult to identify any similarity between Thune's training task (color guessing) and his criterion task (learning a list of paired-associates).

Mandler (1962) has suggested that three kinds of transfer effects can be distinguished, depending on the kind of similarity which exists between training tasks and the transfer task. The first of these is a transfer effect based on overlearning of training tasks in an A-B, A-C experimental design,--hence, where there is cue repetition. The second is a learning-to-learn effect, and the third is a warm-up effect.

Mandler was primarily interested in the stage of learning of training tasks in the A-B, A-C design. Other variables of interest might be similarity of response, time interval between tasks, etc. In order to include all studies involving the A-B, A-C design, Mandler's first kind of transfer will be referred to in this paper as transfer based on cue repetition.

Tasks used in studying transfer effects based on cue repetition often require Ss to learn which cues in a stimulus situation are relevant. A number of studies demonstrate that when a cue is found to be relevant for one task it is more likely to be regarded as relevant for further tasks (Eckstrand and Wickens, 1954; Lawrence, 1949, 1950; and Stolurow and Solley, 1955). When the old cue is indeed relevant for the new task positive transfer is observed. If, however, the old cue is no longer relevant (a nonreversal shift) negative transfer is observed (Harrow and Friedman, 1958; and Kendler and D'Amato, 1955). A summary of effects of nonreversal shifts are summarized in Concept Learning by Hunt (1963, Pp74-78).

The second kind of transfer effect suggested by Mandler is a learning-to-learn effect. The phrase "learning-to-learn" has a number of possible meanings. For example, in popular jargon it might be said that a person is learning to learn when he takes a course entitled "How to study effectively." Here a person might be expected to learn some study techniques which would be useful in a wide variety of tasks.

At the other extreme, Ss in a psychology experiment may learn a very specific solution-rule which is only applicable to a certain type of problem. Harlow has referred to this type of learning to learn as the formation of learning sets (1949, 1960).

In the present paper Mandler's definition of learning to learn will be used. He speaks of learning to learn as the facilitation which occurs when Ss are given a series of repeated and related tasks. Therefore, learning to learn would include both facilitation due to the learning of a solution rule, and facilitation due to the learning of more general techniques for improving performance. Facilitation which occurred when Harlow's (1944, 1960) chimps learned an "oddity principle" is an example of learning to learn which involves the discovery of a solution-rule. An example of learning to learn in which Ss learn more general techniques for improving performance may be found in Thune's (1951) study in which Ss learned a series of lists of paired-associates. In addition to learning individual S-R associations, Ss evidently learned some general techniques which helped them in the learning of further lists.

Although Harlow's studies are perhaps the best known studies of learning to learn, a number of other studies have shown similar results. The facilitation resulting from the learning of completely separate lists of paired-associates in the study by Bruce (1933) and transfer from one psychomotor task to another in a study by Cox (1933) are early examples of learning to learn. More recent studies by Adams (1954), Duncan (1958, 1960), Shepard (1957), and Thune and Eriksen (1960) have also demonstrated positive transfer resulting from practice on tasks related to, but unlike, the criterion task.

The third kind of transfer effect suggested by Mandler is a warm-up effect. Mandler credits Irion (1948) with first identifying this type of transfer. This is a short-term transfer effect which occurs within a particular experimental period. It may be due to attention habits, reduced ension, etc. The facilitation due to color guessing in Thune's experiment (1950) would come under this classification, as would transfer effects obtained in studies by Hamilton (1950) and Mandler (1956). A complete review of the warm-up literature may be found in a recent article by Adams (1961).

Mandler points out the necessity of using control groups in distinguishing between the various kinds of transfer effects. He claims that this has not been done in most studies so that "warm-up and learning set effects...are usually confounded. Thus it is often not determinable to what extent an animal's prior experience in a maze produces varying degrees of specific postural and attentive habits (warm-up) as against non-specific structural effects (learning set)" (1962, Pp. 421). When Thune (1950) attempted to distinguish between warm-up effects and learning-to-learn effects he failed to find any significant differences in favor of his learning-to-learn group.

In most studies of transfer effects based on cue repetition, these effects are confounded both with learning to learn effects and with warm-up effects (D'Amato and Jagoda, 1960; Harrow and Friedman, 1958; Kendler and D'Amato, 1955; and Kendler and Kendler, 1958). In a study by Kelleher (1956) a control group was used in order to distinguish between transfer due to cue repetition and transfer due to learning to learn. All Ss including Control Ss received training on a discrimination task similar to the test task. Group differences during the performance of the test task were therefore attributable solely to conditions of cue similarity between training and test tasks. It was not possible to compare learning-to-learn effects with cue effects because no group performed only the test task.

Thus although the three kinds of transfer suggested by Mandler have been previously demonstrated, there is very little information available as to the relative size of each. One of the major objectives of the present study was, therefore, to compare these three kinds of transfer in one experimental setting.

The second major purpose of this study was to evaluate the usefulness of a novel method of analyzing data. In most transfer studies, transfer scores are used to make inferences about the mediational processes of Ss. For example in the study by Eckstrand and Wickens (1954) the following conclusion was reached. "It may be inferred from the performance on the test tasks (number of trials to criterion) that the prior experience with the relevance and irrelevance of certain dimensions on the first two tasks developed biases which influenced the predominating cue on the third task." It would be more satisfactory if mediational processes of Ss could be identified objectively so that these mediational processes could be used in interpreting transfer effects.

Brunswik (1956) suggested that the learning of mediational processes could be observed in the emergence of correlations between cues and the responses of the Ss. Bruner, Goodnow, and Austin (1956) termed this cue-response correlation "degree of criteriality." Bruner et al. describe cue criteriality in the following manner. "Take the category of things called 'apples' by some particular person. We are interested in those attributes that affect the probability of our person calling an object an apple. Insofar as <u>changes in the values of any particular attribute</u> do not produce changes in the probability of the object being called an apple, we call that attribute noncriterial. Any attribute which when changed in value alters the likelihood of an object being categorized in a certain way is, therefore, a criterial attribute for the person doing the categorizing." (Bruner <u>et al</u>., 1956).

In a number of studies an attempt has been made to identify mediational processes by means of cue criterialities (Azuma, 1960; Cronbach and Azuma, 1961b; McHale and Stolurow, 1962; and Smedslund, 1955). In all of these studies <u>Ss</u> were expected to learn to make scaled responses to displays containing scaled cues. For each <u>S</u> product-moment correlations were computed between the values of cues and the responses made. These correlations (criterialities) were computed over blocks of overlapping trials for each person separately. As predicted, average criterialities for relevant cues tended to rise to the values which would indicate ideal weighting and average criterialities for nonrelevant cues approached zero.

Criterialities computed over blocks of trials are not altogether satisfactory as a means of learning about the mediational processes of <u>Ss</u>. If <u>S</u> develops a classification system for stimulus displays and then responds differently to different classes of displays, this information is lost in criterialities computed over blocks of many trials. According to Cronbach and Azuma (1961a) this seems to be the way <u>Ss</u> viewed the Azuma problem. They concluded that "computing criterialities was a fine way to analyze data under the Brunswikian hypothesis that S responds to an aggregate of stimuli--but is there any objective procedure for inferring how an S forms categories and hypotheses applied with categories?"

There are at least two other situations in which criterialities computed over blocks of trials would not be very useful. Suppose that one wished to study the learning which takes place in a task requiring only five or six trials to a solution. Criterialities computed over a small block of trials would be too unreliable to be very useful. Another situation in which block criterialities are not very useful may be found in studies of transfer effects. For example, suppose that a study were designed to identify transfer effects based on the repetition of relevant cues in two consecutive tasks. In this case one would be interested in demonstrating an increased criteriality for these previously relevant cues on the initial trial of the transfer task, not over a block of trials.

What is needed is a method of computing the criteriality of a cue for a single trial. Although this cannot be done for one individual, it should be possible to compute the criteriality of a cue for a group of individuals on a single trial by presenting each individual with a different display. By this procedure one could compute the single-trial criteriality for each cue for the first trial of a transfer task. This procedure will be followed in this study in order to identify the effects of performing a series of tasks in which the same cues are present.

The two objectives of this study may be translated into the following hypotheses:

1. Three kinds of transfer effects can be identified and compared: an effect associated with cue repetition, a learning-to-learn effect, and a warm-up effect.
2. Cue repetition is expected to result in a negative effect under a condition similar to a nonreversal shift (relevant cues during training become irrelevant during the criterion task) and a positive effect under a condition in which the same cues are relevant for training task and criterion task.
3. On the first trial of the transfer task, single-trial criterialities will be higher for cues previously relevant than for cues previously irrelevant.

# CHAPTER II

# METHOD

## Subjects and Testing Schedule

Altogether, 240 undergraduate college students were used in this study. Group testing procedures were used. The experiment was carried out twice; once using large groups and once using groups of either 7 or 14. The experimental design required the use of 112 Ss.

In the first experiment it was planned to test all Ss at the same time. Due to an error in scheduling, a room large enough to seat only 140 people was assigned for the experiment. When 101 Ss appeared it was necessary for Ss to sit next to each other. Fourteen of these Ss performed in such a way that their data were not usable. Either they failed to follow directions or they failed to complete the training tasks satisfactorily. In order to complete the data for this first experiment, 25 further Ss were tested.

Because of the necessity of replacing so many Ss and because of the adverse testing conditions during the first experiment, the entire experiment was repeated using smaller groups. Within each small group an equal number of Ss was assigned to each experimental condition and to the control group. Two Ss were dropped from the second experiment; one for failing to follow directions and the other for failing to complete the training tasks satisfactorily.

All of the Ss for the first experiment were required to take part in the experiment as part of a course requirement either for introductory psychology or for educational psychology. All of the Ss for the second experiment were volunteers.

## Description of Tasks

Two types of problems or tasks were used in this study. The first of these was patterned after that of Azuma (1960). For this task, S had to learn to make scaled responses by weighting cues; the first type of task will therefore be referred to as a "W" (weighting) task. The second type of task was a conjunctive concept formation task (Bruner et al., 1956) in which a concept was defined by the presence or absence of X's inside two closed figures. This type of task will be referred to as an "X" task.

Type W Tasks. Figure 1 contains three typical stimulus displays used for type W tasks. In order to complete each task S had to learn to make a correct numerical response to each of a series of such displays. After S responded to each display, feedback was given by allowing him to see the correct answer. Correct answers for all displays could be determined by using a formula; the formula changed from task to task. The correct formula for one W task, for example, was as follows: multiply the numbers in the square and the circle by two and one respectively and then add. Using this formula, the correct answers to the three stimulus displays in Figure 1 would be 4, 5, and 6.

The numbers inside only two of the four figures in each display were relevant and these numbers were weighted by sets of constants. The sets of constants for the five W tasks were as follows: 1,1; 2,2; 2,1; 1,3; and $1,\frac{1}{2}$. Information as to which figures contained relevant numbers for each S and for each task will be given in a later section.

Type X Tasks. Figure 2 contains three typical stimulus displays used for type X tasks. S had to learn to label displays as "K" displays

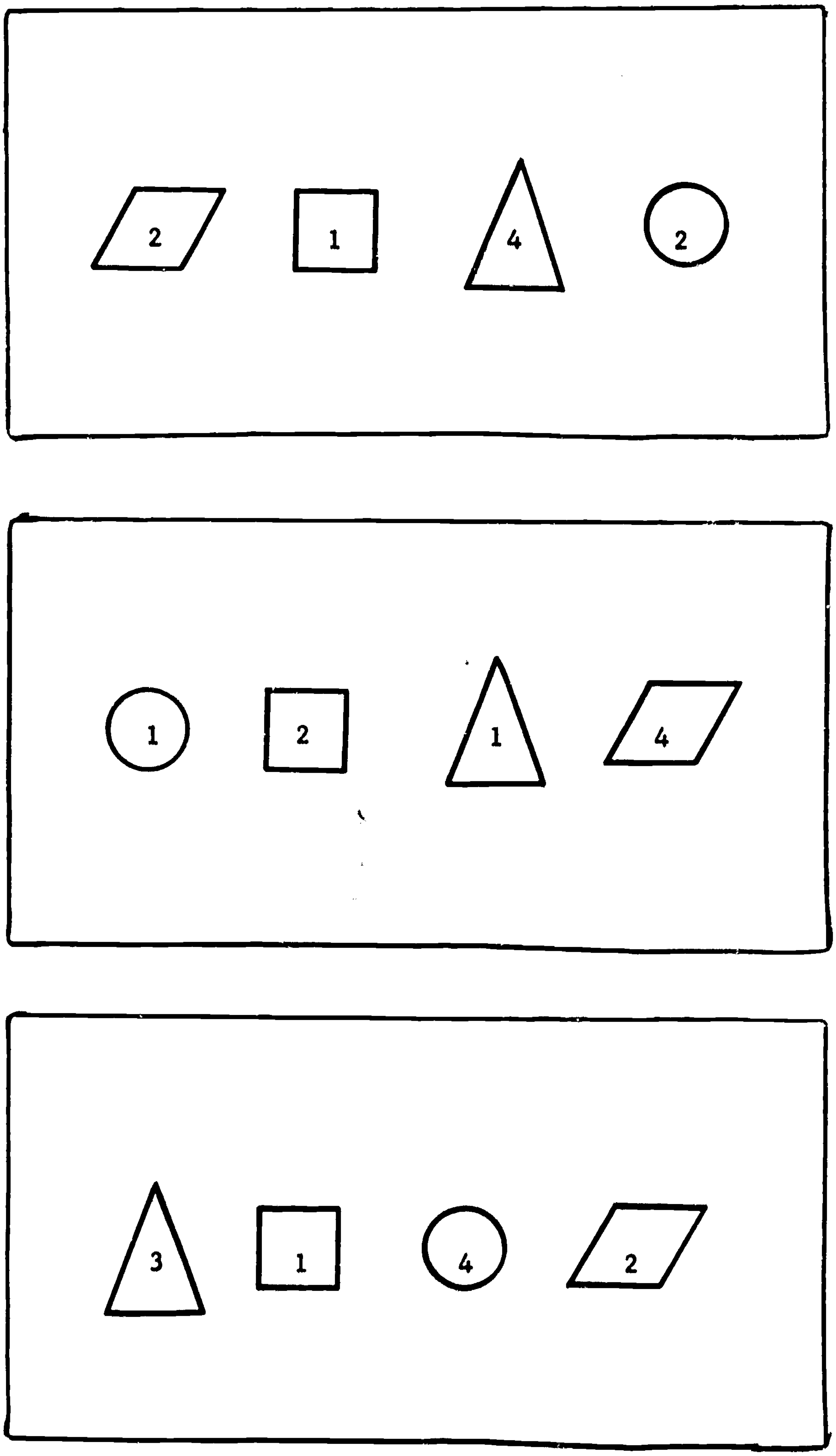



FIGURE 1

TYPICAL STIMULUS DISPLAYS FOR TYPE W TASKS

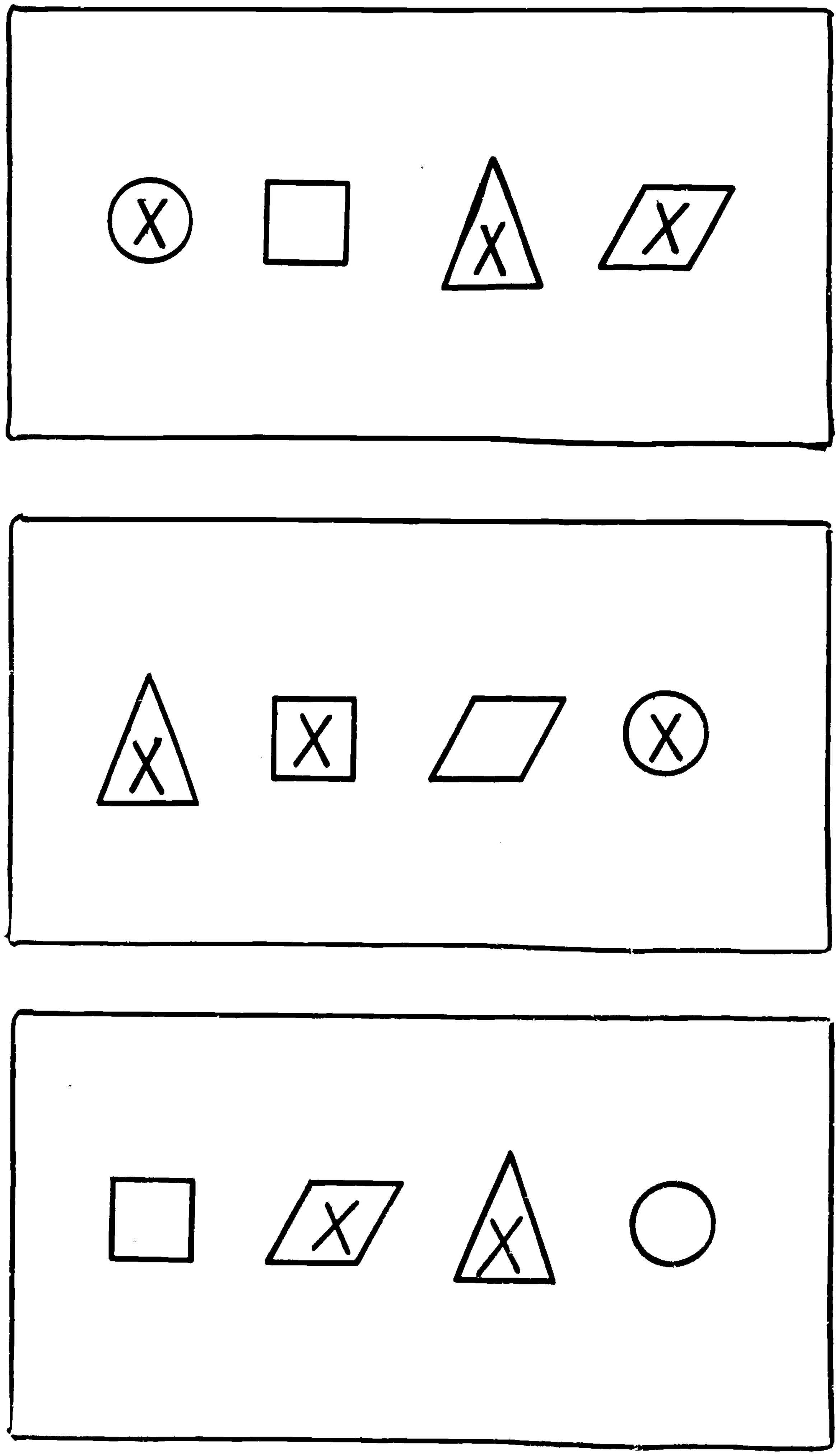


FIGURE 2

TYPICAL STIMULUS DISPLAYS FOR TYPE X TASKS or as "O" displays. After S responded to each display, feedback was given by allowing him to see the correct answer. For each task correct answers for all displays could be determined by using a single rule. The correct rule for the first type X task, for example was: any display in which the circle and the square contain X's is a "K" display; all others are "O" displays. (Actually relevant figures were counterbalanced as will be explained in a later section. Until then descriptions will be given as though the circle and square were always relevant.) Using this rule the correct answers for the three displays in Figure 2 would be O, K, and O.

For each of the three remaining type X tasks S was required to discover a similar rule. These rules for identifying K displays were as follows:

2nd X task - The circle and the square both had to be empty.

3rd X task - The circle had to contain an X; the square had to be empty.

4th X task - The circle had to be empty; the square had to contain an X.

Termination of Tasks. Studies have shown that Ss generally can distinguish examples of a concept before they can verbalize a correct definition of it (Hull, 1920; Smoke, 1932; Walk, 1952; Adams, 1957; and Davis and Hess, 1962). In order for the required mediational processes to be learned in the present study it was necessary that S become aware which cues were relevant for each of the training tasks. The criterion for the completion of each task was 16 consecutive correct responses accompanied by a correct verbalization of the solution.

## Experimental Design

The basic design of this experiment is a factorial design involving two degrees of similarity between training tasks and the criterion task and three degrees of similarity between the cues used for the training tasks and those used for the criterion task (throughout this paper the word "cue" will refer to one of the four closed figures in a stimulus display.) In addition to the six groups (16 Ss per group) necessary for this design, an additional group of Ss was used as a control group. These control Ss performed only the criterion task. Table 1 contains a schematic description of the training and transfer conditions for the seven groups in both experiments.

TABLE 1

SCHEMATIC DESCRIPTION OF TRAINING AND TRANSFER CONDITIONS FOR EACH GROUP

| Group | Training Tasks | | | Criterion Task | | |
|---|---|---|---|---|---|---|
| | Relevant Cues | Irrelevant Cues | Type of Task | Relevant Cues | Irrelevant Cues | Type of Task |
| WS | ab | cd | W | ab* | cd* | W* |
| WO | cd | ab | W | ab** | cd | W* |
| WN | ef | gh | W | ab | cd | W* |
| XS | ab | cd | X | ab* | cd* | W |
| XO | cd | ab | X | ab** | cd | W |
| XN | ef | gh | X | ab | cd | W |
| Control | No Training Tasks | | | ab | cd | W |

*Same as in training
**Formerly irrelevant

Conditions of Task Similarity. Two conditions of similarity between training tasks and the criterion task were used in this study. For all Ss the criterion task was a W task with constants 1/2 and 1. Before performing the criterion task all experimental Ss performed four training tasks. Half of the experimental Ss performed four type W tasks (weights: 1,1; 2,2; 2,1; 1; 3) before performing the criterion task. These Ss will be referred to as W groups. The remaining experimental Ss (X groups) performed four type X tasks before performing the criterion task.

Conditions of Cue Similarity. Three conditions of cue similarity between training and criterion tasks were used. For one third of the experimental Ss the same four cues were present during all tasks and the same two of these four cues were relevant throughout. This is the S (same cue) condition. The S condition is represented in Table 1 by two groups; WS and XS. Ss of the WS group received training on W tasks while Ss of the XS groups received training on X tasks. For example, an XS subject might be trained on tasks where the presence or absence of X's in the circle and square was always significant; in his criterion (W) task the numbers to be weighted appeared in the circle and square.

For another third of the experimental Ss the same four cues were present throughout all tasks but the two cues relevant for training tasks were irrelevant for the criterion task and vice versa (a nonreversal shift). This is the (opposite cue) condition represented in Table 1 by group WO and group XO.

For the remaining experimental Ss four completely new cues, unlike the four present during training task, were introduced for the criterion task. This is the N (new cue) condition. The four cues used during training for the Ss in this third cue condition are shown in Figure 3. For the WN group these figures contained numbers, while for the XN group they were either empty or else they contained X's.

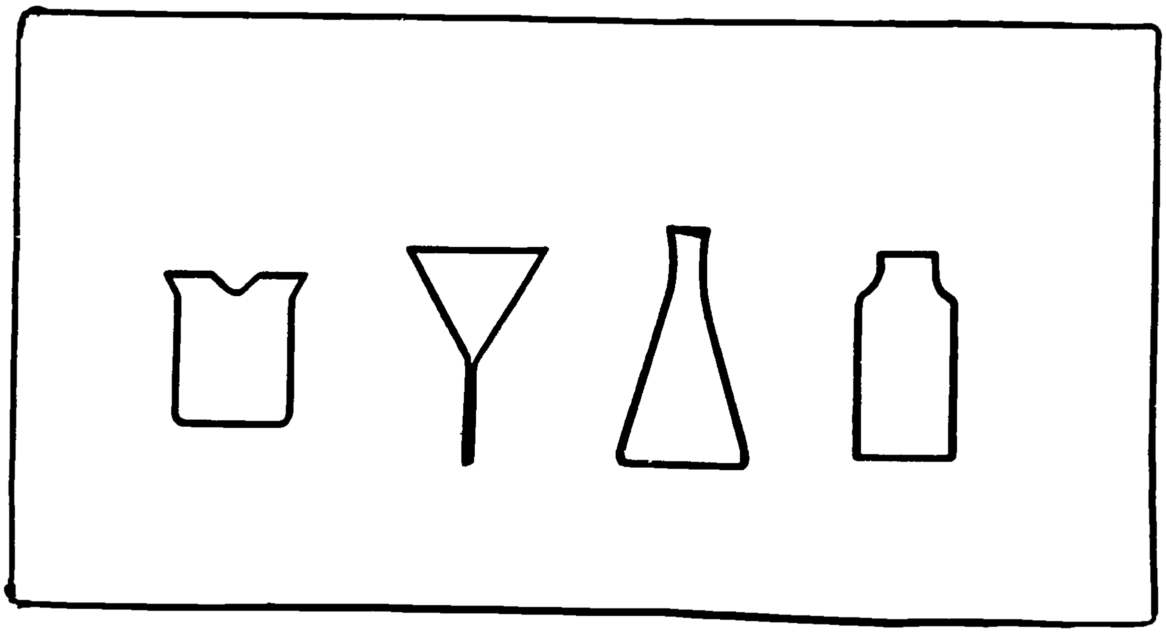


FIGURE 3

CUES USED DURING TRAINING FOR N (NEW CUE) GROUPS

Description of Displays

Order of Cues. The cues did not appear in the same order for all of the 80 displays used for each task. Sixteen of the 24 possible arrangements of the four cues were chosen by E. These orders were then used to make up five blocks of 16 displays each. For a description of these orders see Appendix A.

Symbols within Cues: Type W Tasks. For a study similar to this one McHale and Stolurow (1962) constructed a set of stimulus displays as follows. Within each block of 16 displays all possible combinations of the four values of the two relevant cues occurred once. This made the correlation between these values zero. The distribution of the values of the two irrelevant cues was rectangular. Correlations between all possible combinations of cues and between values of irrelevant cues and correct answers were all less than .10. Correlations between the correct answers and numbers inside the cues weighted 1/2 and 1 were .45 and .89 respectively. The five blocks of 16 stimulus displays used for type W tasks for this study contained the same numbers as the first five blocks of displays used by McHale and Stolurow.

In order to make it possible to compute single-trial criterialities for any given trial, each S within a group had to see a different stimulus display on that trial. This was accomplished by using the cue values of the first 16 displays employed by McHale and Stolurow so that on the first trial all 16 Ss in a group saw different displays. On the first trial, the first S saw display number one; the second S saw display number two; etc. On the next trial all of the displays shifted one position so that at the end of 16 trials every S had seen the same sequence, but each had begun at a different point. On the 17th trial a new set of 16 displays was introduced.

Symbols within Cues: Type X Tasks. For type X tasks there were 16 possible combinations of filled and empty figures. Four out of these 16 possible stimulus displays are examples of whatever conjunctive concept was to be learned. For each block of 16 displays a new random arrangement was used. See Appendix B for a complete description of the 80 displays used for type X tasks.

Rotation of Cues Over Ss. In order to balance the effects of "Eindringlichkeit" (Brunswik, 1938) or initial cue preference, not all

Ss within any group used the same stimulus figures as relevant cues during the criterion task. The choice of relevant cues from among the four geometric figures (a circle, a square, a triangle, and a rhombus) was balancedwithin each group. For the first four Ss in each group K = 1/2 (circle)+ 1 (square), for the next four Ss K = 1/2 (square) + 1 (triangle), etc. Table 2 contains a complete description of the cues which were relevant and the cues which were irrelevant for each S on the criterion task and on the four training tasks.

Method of Presentation and Instructions to Ss.

Description of Booklets. Booklets with different colored covers were made up for each task. Each booklet contained complete written instructions and sample displays. Answers were recorded on separate answer sheets. Booklets were in the "zebra stripe" form with five displays on each page. S followed the proper sequence of displays by responding to only one display on each page and then turning to the following page for the next display. He would thus go through the entire booklet responding to the first display on each page--the one at the top. Then he would return to the front of the booklet and respond to the second display on each page.

The displays and the correct answers appeared on the same page. The answers were covered by tabs of paper which could be lifted to reveal the correct answer.

Written Instructions to Ss. In general the written instructions (see Appendix C) gave two kinds of information which would be of aid in solving the problems. First, the general rule for the solution to

TABLE 2

ASSIGNMENT OF FIGURES AS RELEVANT AND IRRELEVANT CUES

| Groups | Subject Numbers | Training Tasks: Relevant Cues | Training Tasks: Irrelevant Cues | Transfer Tasks: Relevant Cues | Transfer Tasks: Irrelevant Cues |
|---|---|---|---|---|---|
| WS or XS | 1-4 | circle & square | triangle & rhombus | circle & square | triangle & rhombus |
| | 5-8 | square & triangle | rhombus & circle | square & triangle | rhombus & circle |
| | 9-12 | triangle & rhombus | circle & square | triangle & rhombus | circle & square |
| | 13-16 | rhombus & circle | square & triangle | rhombus & circle | square & triangle |
| WO or XO | 1-4 | triangle & rhombus | circle & square | circle & square | triangle & rhombus |
| | 5-8 | rhombus & circle | square & triangle | square & triangle | rhombus & circle |
| | 9-12 | circle & square | triangle & rhombus | triangle & rhombus | circle & square |
| | 13-16 | square & triangle | rhombus & circle | rhombus & circle | square & triangle |
| WN or XN | 1-4 | beaker & funnel | flask & jar | circle & square | triangle & rhombus |
| | 5-8 | beaker & funnel | flask & jar | square & triangle | rhombus & circle |
| | 9-12 | beaker & funnel | flask & jar | triangle & rhombus | circle & square |
| | 13-16 | beaker & funnel | flask & jar | rhombus & circle | square & triangle |
| Control | 1-4 | No Training Tasks | | circle & square | triangle & rhombus |
| | 5-8 | | | square & triangle | rhombus & circle |
| | 9-12 | | | triangle & rhombus | circle & square |
| | 13-16 | | | rhombus & circle | square & triangle |

the problem was given. Second, sample displays along with correct answers were given for the problem about to be undertaken.

For all type W problems the rule for the solution was explained as follows; "The K-value of a display is affected only by the numbers inside two of the figures and K is obtained by multiplying the numbers inside each of these relevant figures by some constant and then adding." For each problem four sample displays with their correct answers were given. In the first sample display each figure contained a numeral "1", in the second each contained "2", etc. Beneath these sample figures S was told that correct answers to displays for that problem would never be greater or less than certain numbers which were given. This was done in order to restrict the range of responses of Ss.

For type X problems the solution rule was explained as follows. "Only two of the four figures are used in determining correct answers, and it is the presence or absence of X's in these two relevant figures which determines whether a display is a K display or not." Two sample displays and their correct answers were given. In the first sample display all figures contained X's; in the second sample display all figures were empty.

Oral Instructions to Ss. After supplying personal data, Ss of the first experiment were told orally: "You are going to be asked to solve a series of problems. Each booklet contains a single problem. You are to work with the booklets in the following order: white, rust, blue, green, and grey. Some of you have only one booklet. In this case you have only one problem to solve. Now everyone turn to the instructions in the first booklet. You are to study the instructions until I tell you to stop, You will have seven minutes. Do not go past the page of sample figures."

After seven minutes the following instructions were given: "I want to emphasize six things which were in the directions. Number one, you are to write an answer for every display before looking at the answer even if you are only guessing. Two, you are to answer only one display on each page before proceeding to the next page. Three, only two figures are relevant in any problem. Four, order of figures within a display is completely irrelevant. Five, when you get 16 consecutive correct answers write the rule which you are using at the bottom of the page and then go to the next problem. And finally six, the directions indicated that you would be told when twenty seconds had elapsed so that you could pace yourself. You need not feel forced to keep exact pace with the timer. However you should use the timer as an approximate timing device if you are going to finish these problems in the required time. (For both experiments a tape recorder was used as a timing device. A loop of tape containing the single word "turn" was played through the recorder every 20 seconds.)

"Now, those of you who would like to may spend some more time on the instructions and the rest of you may begin on the first task whenever you are ready."

For the second experiment the only change in the oral instructions was that S was told to have each solution checked before proceeding to the next problem.

In both experiments any S who had failed to solve the first task at the end of 80 trials was told to lift all of the tabs from several pages so that he could examine several displays and answers simultaneously. Under these conditions all Ss solved the first task.

Predicted Results

A number of predictions were made during the planning of this experiment. There were, first, predictions about the relative number of errors each group would make on the criterion task, and second, predictions regarding the criterialities of the several cues during the criterion task.

The following predictions were made about criterion task performance.

1. S (same cue) groups would make fewer errors than N (new cue) groups, while O (opposite cue) groups would make more errors than N groups.
2. W (type W training tasks) groups would make fewer errors than X (type X training tasks) groups.

The first prediction is based on the hypothesis that S groups would show positive transfer due to the repetition of relevant cues and that the O groups would show negative transfer due to the reversal of relevant and irrelevant cues. N groups provided a basis for comparison since neither facilitating nor interfering effects from cue similarity were expected. The second prediction is based on the hypothesis that W groups would exhibit a learning-to-learn effect.

Warm-up effects differ from learning-to-learn effects in two ways: first for warm-up effects there is a lack of similarity between training and criterion tasks, and second, warm-up effects are very sensitive to the time interval between training and criterion tasks (Adams, 1961). In the present experiment the difference between the performances of the XN group and the control group will be referred to as a warm-up effect on the basis of the lack of similarity between the training tasks and the criterion task for the XN group. The design of the experiment did not include as a variable the time interval between tasks. Such a design would of course be possible. If the effect which has been labeled a warm-up effect is correctly labeled this effect should be sensitive to the length of the interval between training and criterion tasks.

The following predictions were made regarding the single-trial criterialities of the cues on the criterion task:

1. For S and O groups single-trial criterialities for the first trial of the criterion task will be greater for cues relevant on preceding tasks than for cues irrelevant on preceding tasks.
2. For control groups and for N groups there will be no differences larger than chance expectancy among the single-trial criterialities of cues on the first trial of the criterion task.
3. For all groups single-trial criterialities for relevant cues will approach the correct criterialities of .44 and .89 (see section entitled Description of Displays.) For non-relevant cues the single-trial criterialities will approach zero.

# RESULTS

## Group Differences

Error Scores. The score used as a measure of the rate of learning was the number of errors made by S before reaching the criterion of 16 consecutive correct answers. For each task the minimum error score possible would be zero, for Ss who responded correctly for the first 16 displays; this could occur only with very lucky initial trials. The maximum error score possible would be 80, for Ss who failed to make correct responses for any of the 80 displays. Total error scores were used rather than number of trials to criterion to avoid placing undue emphasis on chance errors in arithmetic. Once S reached criterion, all remaining trials were considered correct. Appendix D contains a complete listing of the number of errors made by each S on each task. Groups means, medians, and standard deviations are also included.

Because the variance of error scores within groups was not homogeneous, a logarithmic transformation was applied to the error scores before any analysis was undertaken. Since there were some zero error scores it was necessary to take the log of (X + 1) rather than log X. The logarithmic transformation served the additional purpose of reducing the influence of extreme scores upon the group means.

Equivalence of Experiments and Groups within Experiments. In order to test for equivalence of experiments and groups within experiments, a three-way analysis of variance was performed on the transformed error scores for the fourth training task. The requirement of homogeneity of variance for these scores was satisfied according to Bartlett's test

(1937). Table 3 summarizes the analysis.

TABLE 3

ANALYSIS OF VARIANCE FOR TRANSFORMED[a] ERROR SCORES FOR THE FOURTH TRAINING TASK

| Source | df | ms | F |
|---|---|---|---|
| Blocks[b] | 1 | .014 | .121 |
| Rows | 1 | .696 | 5.645* |
| Columns | 2 | .066 | .535 |
| B x R | 1 | .119 | .966 |
| B x C | 2 | .142 | 1.152 |
| R x C | 2 | .014 | .120 |
| R x C x B | 2 | .042 | .338 |
| Within | 180 | .123 | |
| Total | 191 | | |

[a]Scores transformed by using log (X + 1).

[b]Blocks refers to experiments, row to type of training task, and columns to cue conditions.

*Significant at .05 level.

In Table 3 the only significant F value is associated with type of task. The mean of the transformed error scores for type W training tasks is significantly larger than the mean for type X tasks. This reflects the obvious difference in task difficulty. Since the analysis of variance failed to show any significant differences between experiments the results of the two experiments were pooled for all further analyses of error scores. Also since no significant differences were found for cue conditions (columns) it was concluded that the random assignments of Ss to groups had resulted in groups of similar ability.

Average Error Scores on the Criterion Task. Table 4 contains the means and standard deviations of the transformed error scores for each group on the criterion task.

TABLE 4

MEANS AND STANDARD DEVIATIONS OF TRANSFORMED[a] ERROR SCORES ON THE CRITERION TASK

| Type of Training Task | | Cue Condition S | O | N | Groups Pooled |
|---|---|---|---|---|---|
| W (N = 32 in each group) | M = | .651 | .747 | .589 | .662 |
| | S.D. = | .437 | .311 | .353 | .373 |
| X (N = 32 in each group) | M = | .841 | .771 | .843 | .819 |
| | S.D. = | .334 | .440 | .485 | .421 |
| Experimental Groups Pooled | M = | .746 | .759 | .716 | .740 |
| | S.D. = | .398 | .378 | .439 | .404 |
| None (Control group; N = 32) | | -- | -- | -- | 1.267 |
| | | -- | -- | -- | .440 |

[a]Scores transformed by using log (X + 1).

A three-way analysis of variance was used to test the predictions about group means. Again the logarithmic transformation which was used resulted in homogeneity of variance. Table 5 reports the analysis of variance.

The first prediction made concerning average group error scores on the criterion task involved the order of means for the three cue conditions. It was predicted that the order of error scores for cue groups (pooled) would be: smallest S, then N, largest O. These means are .746, .716, and .759. Differences between these means are not significant.

When average error scores for cue groups are compared independently

TABLE 5

ANALYSIS OF VARIANCE FOR TRANSFORMED[a] ERROR SCORES FOR THE CRITERION TASK

| Source | df | ms | F |
|---|---|---|---|
| Blocks | 1 | .003 | .016 |
| Rows | 1 | 1.170 | 7.245** |
| Columns | 2 | .031 | .191 |
| B x R | 1 | .122 | .754 |
| B x C | 2 | .028 | .175 |
| R x C | 2 | .224 | 1.383 |
| R x C x B | 2 | .147 | .911 |
| Within | 180 | .162 | |
| Total | 191 | | |

[a]Scores transformed by using log (X + 1).

[b]Blocks refers to experiments, row to type of training task, and columns to cue conditions.

**Significant at .01 level.

for each type of training task, there appears to be an interaction effect. Under the W training condition the O group made more errors than either other group while under the X training condition, the O group made fewer errors than either other group. However, the analysis of variance reported in Table 5 indicates that this interaction effect is not significant. The first prediction therefore was not confirmed. Although all of the experimental groups showed positive transfer when compared to the control group no net effect was found for cue conditions.

The second prediction, that the average error score for W groups would be less than that for X groups, was confirmed. The means for these groups were .662 and .819 respectively ($P < .01$). This is interpreted as showing the presence of a learning-to-learn effect.

In order to test for the presence of a warm-up effect a t test was used to compare the average transformed error score of the XN group with that of the control group. The means for these two groups, .843 and 1.267 differed significantly ($P < .005$).

Group Differences in Errors-Per-Trial. Within group error scores for each of the first 32 trials were computed. Graphic summaries by blocks of trials appear in Figures 4, 5, and 6 (see also Appendix E). The results are consistent with the analysis of variance (Table 5). In Figures 4 and 5 there is not a consistent difference in favor of any cue group. An interaction effect, possibly significant, appears. The WO group had some initial disadvantage on the criterion task, compared with WS and WN groups. The XO group, on the other hand, was not so handicapped compared with the XS or XN groups.

In Figure 6 the number of errors made for blocks of four trials by Ss in W groups is consistently less than the number of errors made by Ss in S groups. This again is evidence of a learning-to-learn transfer effect for Ss of W groups.

Differences in Cue Criterialities.

First-Trial Differences. In this study single-trial criterialities were proposed as a means of identifying sources for observed transfer effects. Primary interest therefore was centered on the initial trial of the criterion task. On the first trial of the criterion task each S made a response to a display containing four scaled cues. For each group of Ss a correlation coefficient was computed between cue values and responses (trial 1, Appendix E). With an N of 16 these criterialities

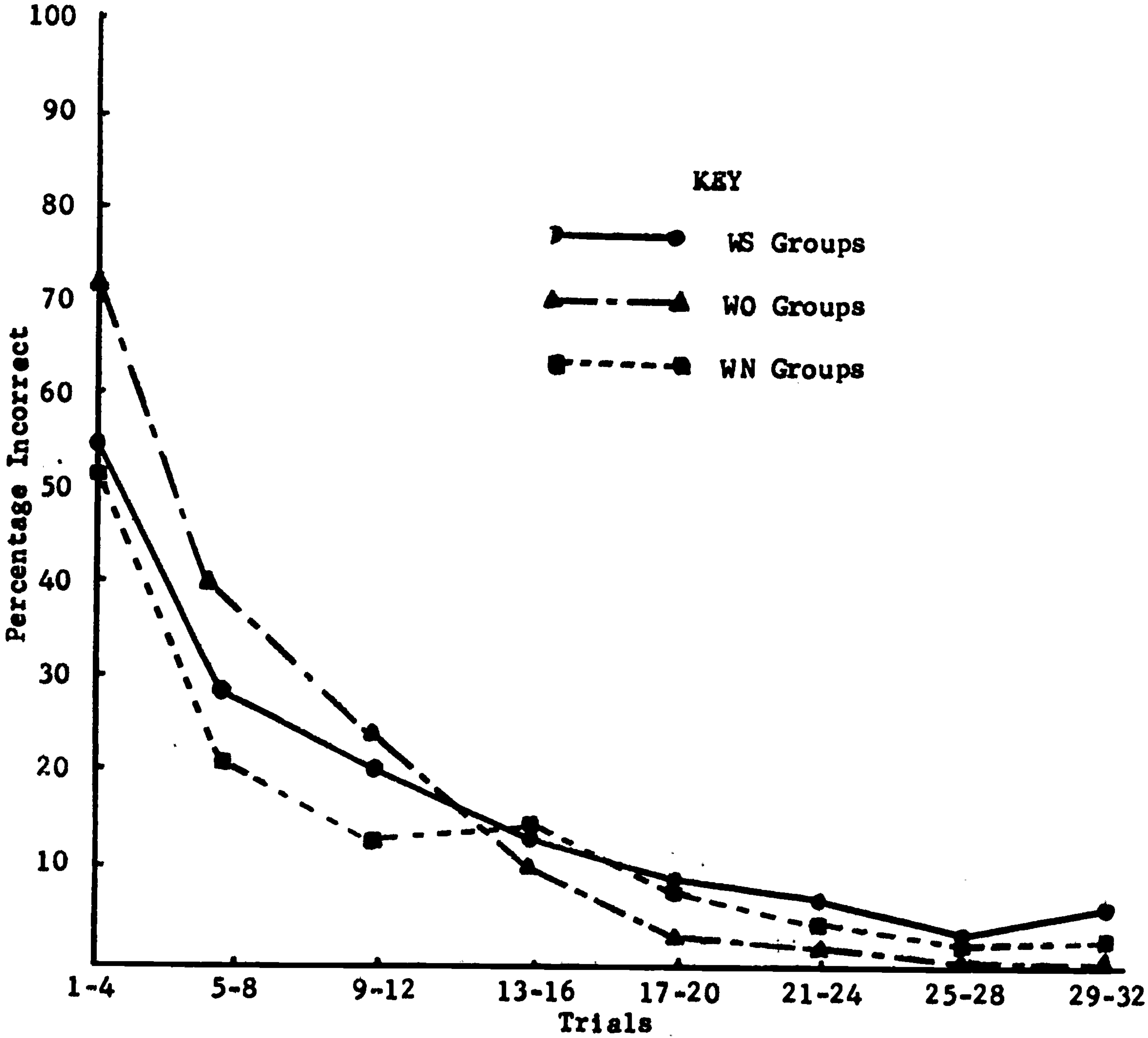



FIGURE 4
PERCENTAGE OF INCORRECT RESPONSES FOR BLOCKS OF FOUR TRIALS ON THE CRITERION TASK--WS, WO, AND WN GROUPS

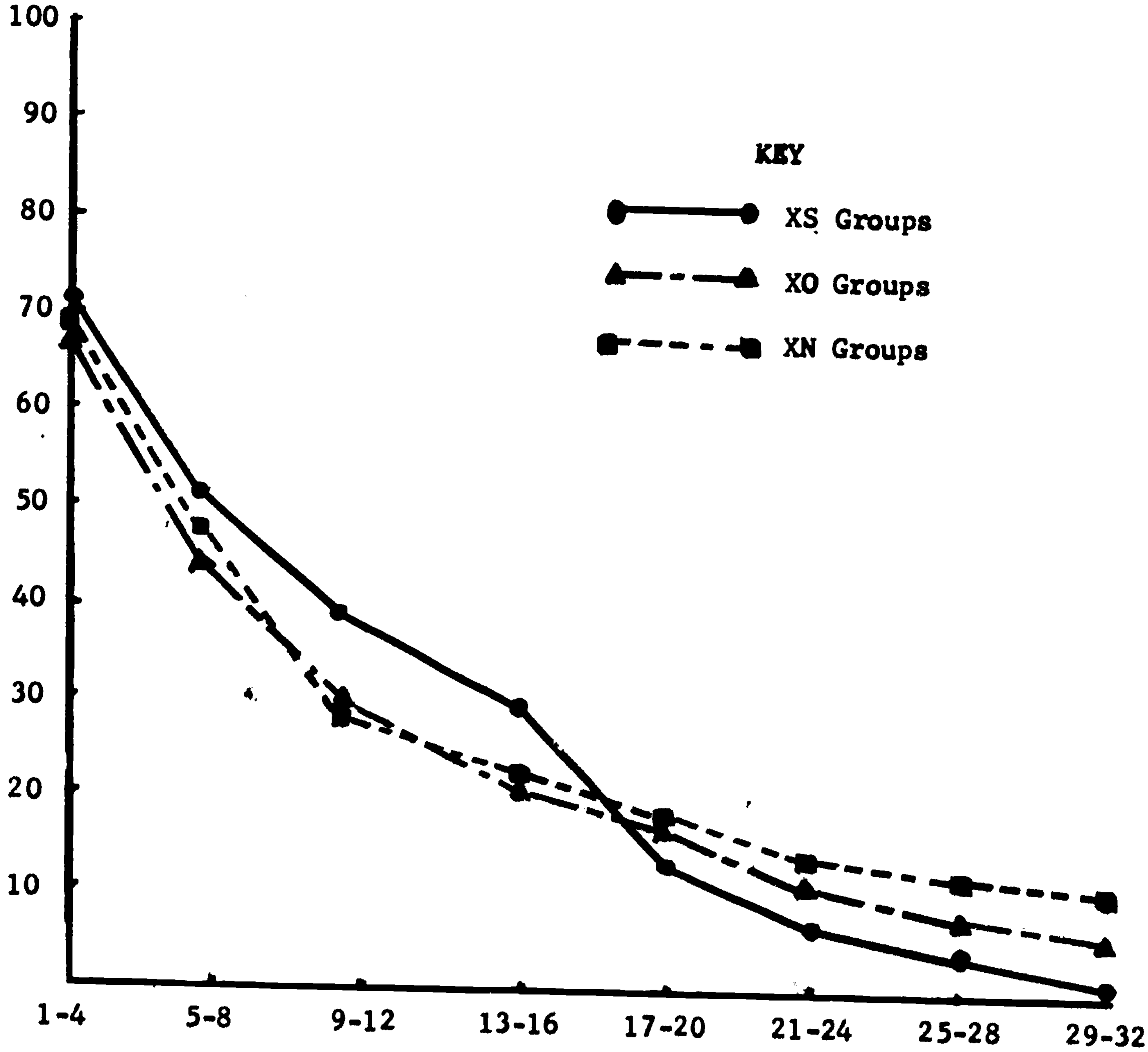



FIGURE 5
PERCENTAGE OF INCORRECT RESPONSES FOR BLOCKS OF FOUR TRIALS ON THE CRITERION TASK--XS, XO, AND XN GROUPS

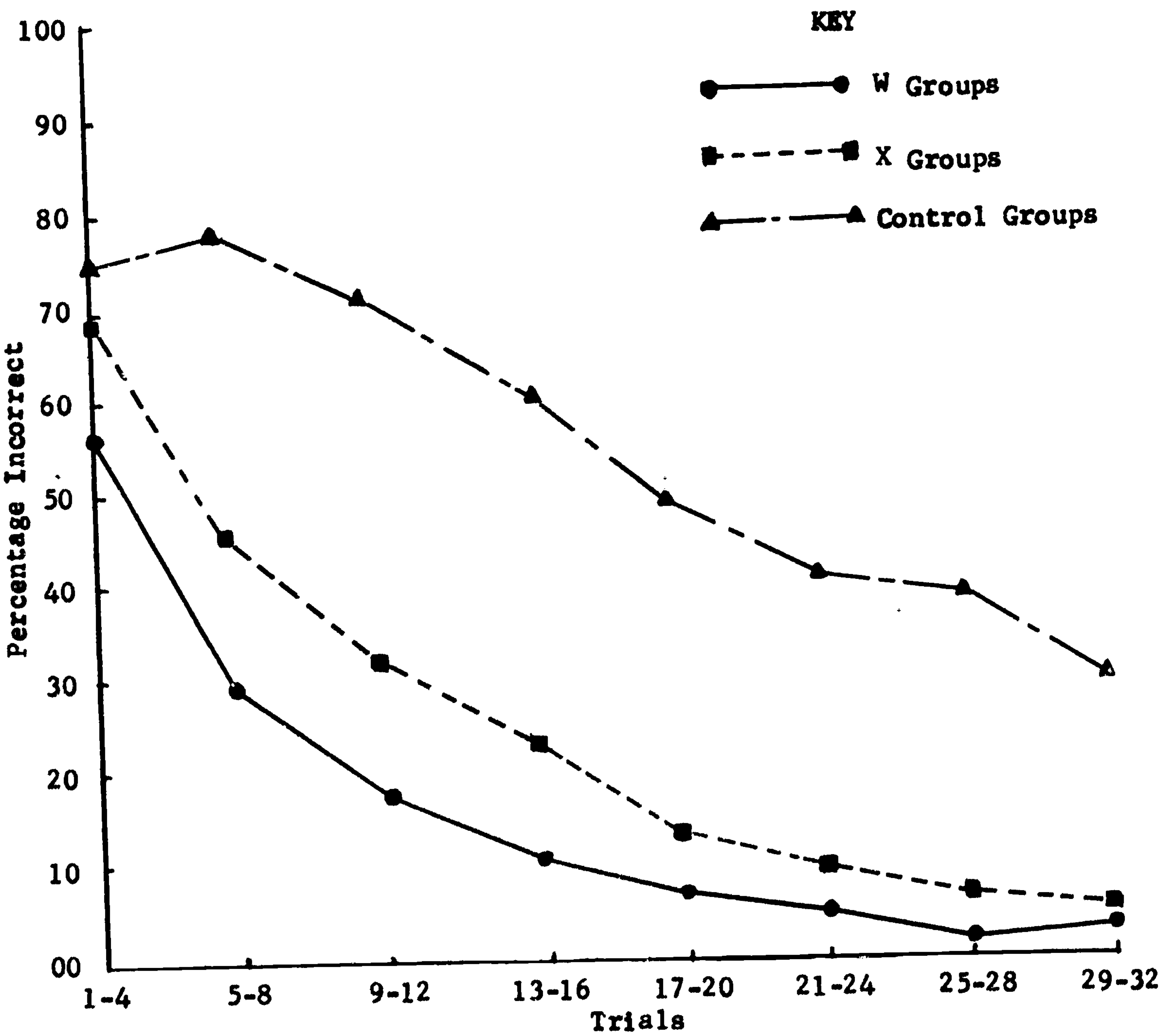



FIGURE 6
PERCENTAGE OF INCORRECT RESPONSES FOR BLOCKS OF FOUR TRIALS ON THE CRITERION TASK--W, X, AND CONTROL GROUPS
(Cue conditions Pooled)

are not very stable Two steps were taken to increase N. First, data from the two experiments were pooled. Second, instead of computing the criteriality of each of the four cues separately, one criteriality was computed for the two relevant cues and another for the two irrelevant cues. This brought N for each criteriality to 64 (16 Ss in each of two experiments and two of each type of cue for each display). Table 6 contains the criterialities which resulted.

TABLE 6

CRITERIALITIES OF RELEVANT AND IRRELEVANT CUES ON THE FIRST TRIAL OF THE CRITERION TASK (N = 64[a])

| Group | Cues Relevant on Criterion Task | Cues Irrelevant on Criterion Task | Difference[b] |
|---|---|---|---|
| WS | .27 | .07 | 20 |
| WO | -.02 | .44 | -.46 |
| WN | 27 | .11 | 16 |
| XS | .68 | -.17 | .85 |
| XO | - 04 | .29 | 33 |
| XN | .25 | .14 | .11 |
| Control | .35 | .04 | 31 |

[a]Two entries per person.

[b]No exact significance test available (see page 33).

It was predicted that criterialities for cues which had been relevant on previous tasks would be larger than the criterialities for cues which had been irrelevant. For Table 6 this means that for WS and XS groups, relevant cues should have larger criterialities of the irrelevant cues; for WO and XO groups, criterialities of the irrelevant cues should be greater since relevant and irrelevant cues had been reversed For all four of these groups the results are in the predicted direction. For the control group and for the WN and XN groups no differences between the criterialities of the four cues on the first trial of the transfer task were expected.

There is not a suitable significance test for differences between criterialities because criterialities of the four cues are not independent. In order to make a test of significance possible the sum of relevant cues minus the sum of irrelevant cues was computed for each display. Correlating this sum with S's responses gave a sort of criteriality for relevant-minus-irrelevant cues. The values were: S groups, .38; O groups, -.40; and N groups, .14. With an N of 64 the values for S and O groups are significant at the .005 level. These results tend to confirm the predictions that were made.

The difference between criterialities of relevant and irrelevant cues for the control group (Table 6) is difficult to interpret. Nothing in the experimental design could account for this result. It must be assumed either that this is a chance effect or that some Ss looked at the first answer before responding. Some members of the control group may have inadvertently exposed the answer to the first display since they had not received previous training with the form of presentation used. An examination of errors made on the first few trials in the control group supports this explanation. Fewer errors were made on trial one than on any trial from two to nine. For other groups (See Appendix E) the greatest number of errors occurred on the first trial, except for group XN where there was one more error on trial two than on trial one.

Effects of Learning. The third prediction concerning cue criterialities was that the criterialities of relevant cues would approach the ideal values of .44 and..89 and the criterialities of irrelevant cues would approach zero. Single-trial criterialities were computed for each group for every trial of the criterion task. Criterialities for the first 40 trials are reported in Appendix G. Criterialities for the remaining trials are not reported because beyond this point fluctuations were usually the result of changes in the responses of a single S. An examination of the criterialities in Appendix G reveals that for all groups the criterialities of relevant cues approached the ideal criterialities of .44 and .89 while criterialities of irrelevant cues approach zero.

The early effects of learning on the cue criterialities for the three cue conditions are shown in Figures 7, 8, and 9 (data in Appendix H). An analysis of additional trials would merely show a further increase in the criterialities of relevant cues and a decrease in the criterialities of irrelevant cues. These data were obtained by averaging the absolute values of the single-trial criterialities appearing in Appendix G. Two steps were taken in order to give these criterialities more stability. First, the two relevant and the two irrelevant cues were combined. Second, criterialities of cues were averaged for every two overlapping trials. Points on the graph in Figures 7, 8, and 9 thus represent the average of 16 criterialities (two experiments, two cues, two trials, and two training groups).

For all groups the average criterialities of relevant cues should increase and the criterialities of irrelevant cues should decrease. For S groups the criterialities of relevant cues should be higher initially than the criterialities of the irrelevant cues. For O groups the criterialities of relevant cues (previously irrelevant) should be initially lower than the criterialities of irrelevant cues (previously relevant).

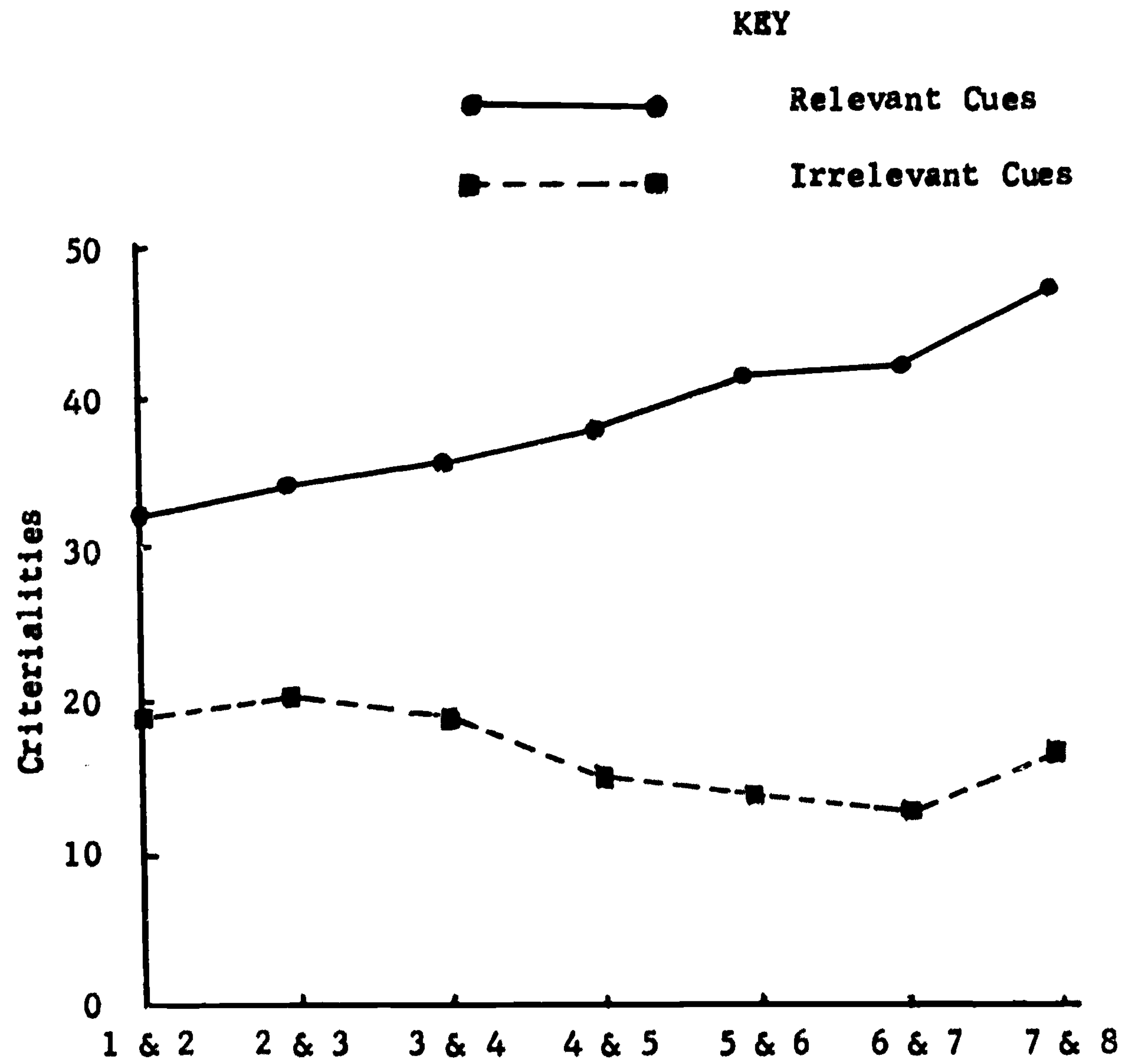



FIGURE 7

AVERAGE RELEVANT AND IRRELEVANT CUE CRITERIALITIES
FOR OVERLAPPING TRIALS ON THE CRITERION TASK--SAME CUE GROUPS

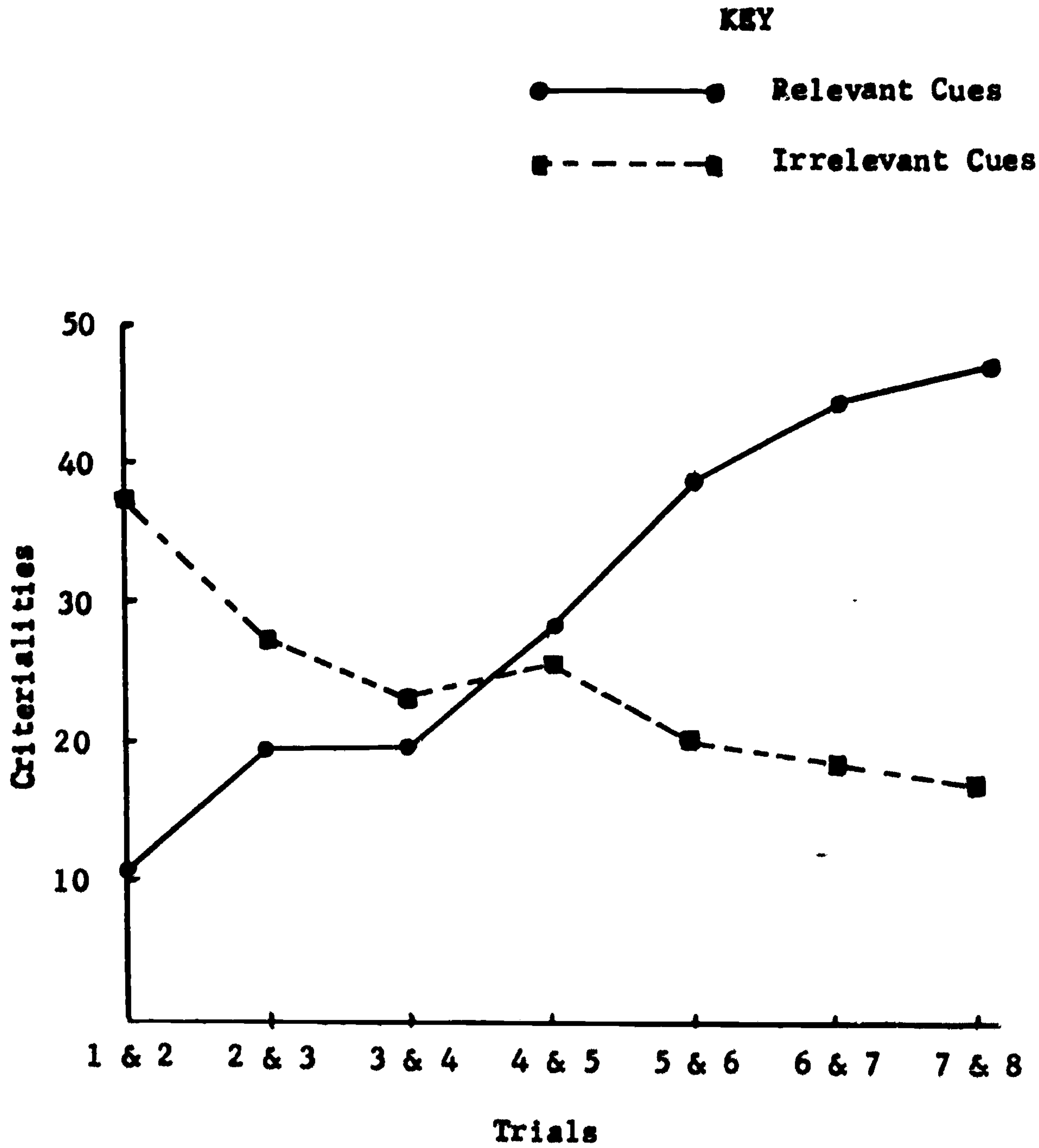



FIGURE 8

AVERAGE RELEVANT AND IRRELEVANT CUE CRITERIALITIES FOR OVERLAPPING TRIALS ON THE CRITERION TASK--OPPOSITE CUE GROUPS

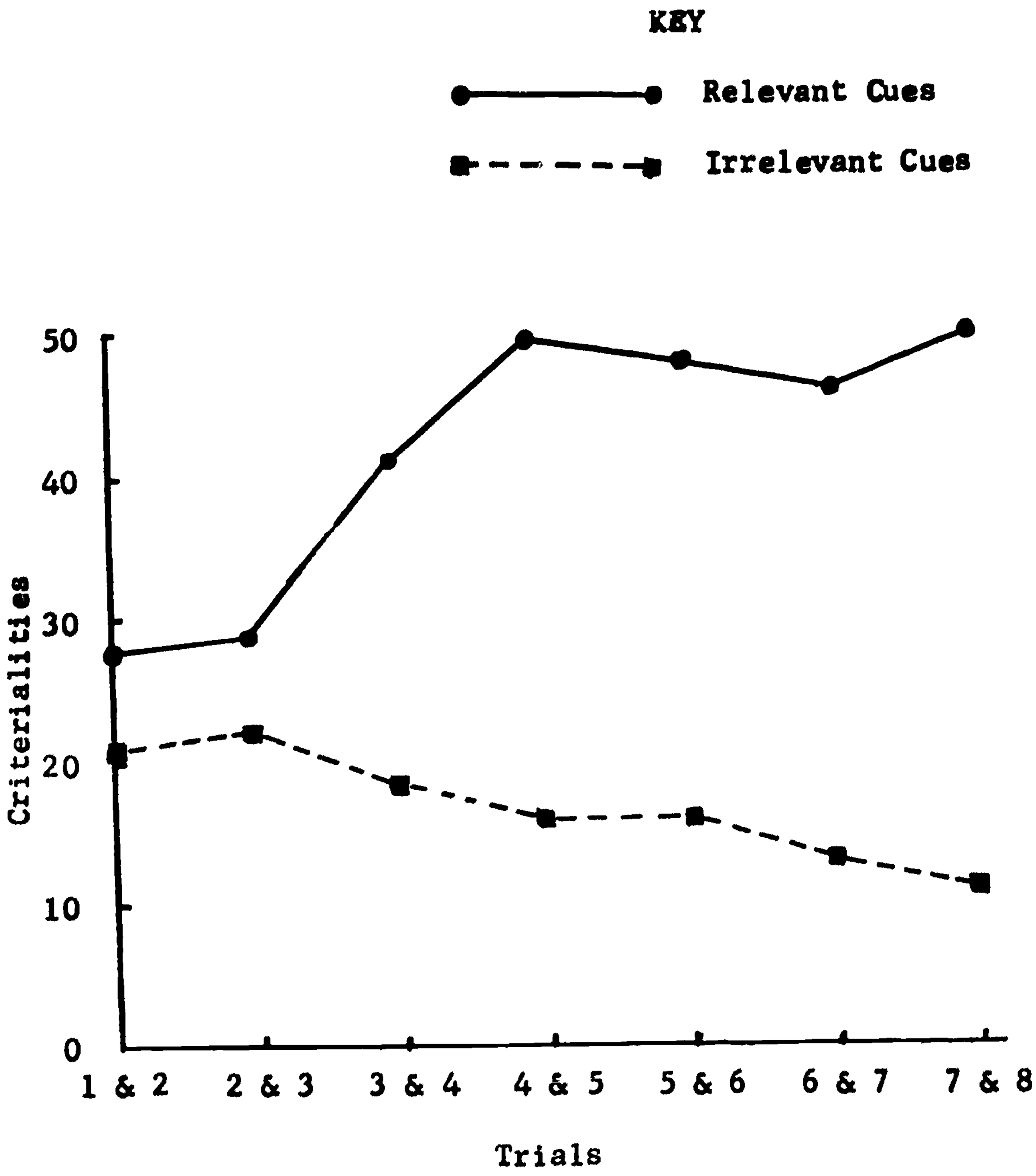



FIGURE 9

AVERAGE RELEVANT AND IRRELEVANT CUE CRITERIALITIES FOR OVERLAPPING TRIALS ON THE CRITERION TASK--NEW CUE GROUPS

For N groups the initial criterialities of relevant and irrelevant cues should be approximately the same. Only for the O groups should there be a crossover as learning takes place. The results shown in Figures 7, 8, and 9 conform very well with these expectations.

Figures 7, 8, and 9, together with the analysis of first trial criterialities, provide evidence of cue-repetition effects (facilitation in S, interference in O), consistent with the second hypothesis. These effects were not significant in Table 5, presumably because Ss had to know both which cues were relevant and how to weight these cues in order to avoid errors.

Single-subject criterialities were also computed for each S for the first block of 16 trials in order to compare the two kinds of criterialities (single-trial versus single-subject). The single-subject criterialities appear by group in Appendix I. For the purpose of this study these single-subject criterialities are not very meaningful because much learning occurred within the first block of 16 trials.

# CHAPTER IV

## DISCUSSION

The results of this experiment will be discussed in reference to the hypotheses tested and the predictions originally made.

### Error Scores.

The first hypothesis was that through the use of the proper control groups it would be possible to identify and compare three kinds of transfer effects in a single study. The three kinds of transfer were the same as those described by Mandler (1962): an effect based on cue repetition, a learning-to-learn effect, and a warm-up effect. Related to the first is the second hypothesis, that for the effect associated with cue similarity both a negative and a positive transfer effect could be identified.

These two hypotheses resulted in the following predictions regarding group performances on the criterion task.

1. S groups would make fewer errors than N groups, whereas O groups would make more errors than N groups.
2. W groups would make fewer errors than X groups.

No prediction was made concerning the number of control group errors. This was, however, compared to the XN group (type X training tasks, new cues). Any difference in favor of the SN group would suggest a warm-up effect.

The predictions concerning the effects of cue repetition on error scores were not confirmed. Same cue groups, opposite cue groups and new cue groups did not differ significantly. Several possibilities could account for this result.

The first possibility would be that the training which Ss received prior to the criterion task did not result in a bias in favor of certain cues for the criterion task. This possibility may be ruled out, in view of the criterialities of cues early in the criterion task.

Another possibility is that the instructions and the sample displays allowed Ss to guess correct weight before identifying relevant cues. It is also possible that the instructions and the feedback given after each trial provided enough information so that relevant cues were easily identified once correct weights were guessed. This explanation seems quite reasonable since an S who knew what weights to use and which cues were relevant would still have to guess which weights to apply to which cue. Another S knowing only what weights to use would have to choose two cues at random for the first trial. After receiving feedback in the form of the correct answer for the first trial it would be possible in many cases for both Ss to solve the problem. For example suppose Ss were shown a display containing cues with the following values 4, 3, 1, 2. If the correct answer to this display is 2.5 and S is quite sure that the weights are 1 and 1/2 only one solution is possible. The cue containing the 1 must be weighted 1/2 and the cue containing the 2 must be weighted 1.

One other possibility which may account for the failure to find significant differences between cue conditions is that the measure used as the rate of learning was not sensitive enough. Since time limits were not rigidly imposed for each trial, an error score of 4 for one S could represent 4 trials requiring 40 seconds and for another S the same error score might represent 4 trials requiring four minutes.

Probably both of the factors which have been mentioned (amount of information given and lack of a strict control for time) contributed to the failure to find significant differences between cue conditions. This is a question which can be answered only by further studies.

The prediction regarding a learning-to-learn transfer effect was confirmed. The usual way to demonstrate learning to learn is to have Ss perform a series of related tasks of equal difficulty. A learning-to-learn curve can then be drawn by plotting the performance of S or a group of Ss for each task. In this study in which tasks were not of equal difficulty, a learning-to-learn curve would not be meaningful. However, if learning to learn is defined as better performance (compared with a control group) following performance of a series of related tasks, it should be possible to demonstrate this accumulated transfer effect at any point in the series. To avoid confounding learning-to-learn effects with warm-up effects it is necessary to provide this control group with a series of unrelated preliminary tasks. In this study W groups did better than X groups on the criterion task demonstrating the predicted accumulated learning-to-learn effect.

A warm-up effect would be expected to result in the XN group doing better on the criterion task than the control group. The difference found was substantial, indeed (see Table 4), larger than the learning-to-learn difference between the XN group and the WN group. This finding emphasizes the importance of controlling for warm-up when studying learning to learn.

It is important to control for learning-to-learn effects as well as for warm-up effects in the study of transfer associated with cue similarities.

A number of studies have compared reversal shifts and nonreversal shifts. In several of these studies an attempt has been made to determine the direction of transfer (D'Amato and Jagoda, 1960; Harrow and Friedman, 1958; Kendler and D'Amato, 1955; Kendler and Kendler, 1959; and Kelleher, 1959). Only Kelleher's control group received training on a task similar to the criterion task so that the effects of reversal and nonreversal shifts would not be confounded with learning-to-learn and warm-up effects. In Kelleher's study both reversal and nonreversal shifts produced negative transfer effects. In the other four studies the performance of Ss who had received training on one or more tasks was compared with that of Ss without previous training. Under these circumstances a positive transfer effect reported after a reversal shift might actually be a negative effect masked by positive learning-to-learn and warm-up effects. If, in our study, only the WO and control conditions had been employed, a positive transfer effect for a nonreversal shift would be reported rather than a finding of no significant difference.

Criterialities.

The third hypothesis was that training on a series of tasks in which the same cues were relevant would result in a bias in favor of the use of these cues on the criterion task and that this bias could be demonstrated by the use of single-trial criterialities. This hypothesis resulted in the following predictions:

1. For S and O groups single-trial criterialities for the first trial of the criterion task would be greater for cues relevant on preceding tasks than for cues irrelevant on preceding tasks.

2. For control groups and for N groups there would be no differences larger than chance expectancies among the single-trial criterialities of cues on the first trial of the criterion task.

3. For all groups single-trial criterialities for relevant cues would approach the ideal criterialities of .44 and .89. For nonrelevant cues the single-trial criterialities would approach zero.

The differences between criterialities of relevant and irrelevant cues on the first trial of the criterion task (Table 6) were consistent with the first prediction. No direct test for significant differences between these criterialities was possible. However an indirect test confirmed the prediction that Ss would use previously relevant cues in responding on the first trial of the criterion task ($P < .005$).

Since the second prediction was one of no significant difference this prediction could not be confirmed; it could only be disproved. For the control group the difference between the relevant and irrelevant cues on the first trial of the criterion task approached significance. This was interpreted as an artifact of the testing situation and not as evidence disconfirming the prediction.

The third prediction regarding cue criterialities was confirmed. For all groups the single-trial criterialities for cues tended to approach the ideal criterialities.

Single-trial criterialities provided useful information in this study, helping to explain the lack of significant differences among cue conditions. Since the criterialities indicated that Ss were biased in their selection of cues on the criterion task some other explanation for the lack of significant differences in error scores was necessary. If the study were repeated, emphasis would be placed on getting a more sensitive measure of rate of learning and on reducing the amount of information given to Ss. No further effort would be made to make cues more distinctive or to increase the number of times the cues were used in training tasks.

Single-trial criterialities should be useful in other experiments besides those in which transfer effects are studied. Extended blocks of trials are not necessary in order to compute single-trial criterialities. This means that single-trial criterialities can be used for tasks requiring only a few trials to solution, if there is a suitable rotation of cue values over subjects.

Using single-trial criterialities it would also be possible to study the effect of a type of display within a sequence of displays. For example, in our W task, limits for correct answers were given at the start of each task. Therefore, Ss should be able to learn more from an initial display in which the correct answer is at either extreme than when it is in the middle of the range. When the correct answer is a maximum, only those cues containing maximum numbers can be relevant. Similarly, when K is a minimum only those cues containing minimum numbers can be relevant. To see whether Ss actually get more information from these displays a sequence of trials could be set up so that single-trial criterialities could be computed for the trial immediately following maximum or minimum K-displays and immediately following displays in which K values were of average size. These criterialities would be useful even when Ss had not yet discovered proper weights and so would give more information than counts of successes.

By using single-trial criterialities on the Azuma task it should be possible to study the rates at which Ss learn to respond correctly to the various classes of stimulus displays. In order to do this it would be necessary to develop a set of displays in which type of display is held constant for each trial within a group of Ss. Cronbach and Azuma (1961a) report that Ss divide the stimulus displays into four classes. A series of stimulus displays could be developed so that for every block of four trials the order of the four classes of displays is randomized or systematically varied. By using such a sequence of displays, single-trial criterialities could be used to compare the rates at which the four classes of displays are learned.

The title of one of the papers listed in the bibliography is "Can we tell what the learner is thinking from his behavior?" (Cronbach and Azuma, 1961b) The results of this study indicate that to a limited extent it is possible to identify what thoughts are most prominent within a group of learners by the use of single-trial criterialities. Even if completely accurate introspective reports were available it would be difficult to demonstrate the effect of a cue reversal any more clearly than the results which are shown in Figure 8.

Situations in which single-trial criterialities are obtainable are admittedly rather limited when compared with the wide range of tasks used in the investigation of human problem solving ability. Nevertheless the technique of this study does provide an objective method of identifying mediational processes during the solution of tasks similar to those of this study. As such it should be a useful research tool in the investigation of human problem solving ability.

Conclusions.

The study assessed independently three kinds of transfer effects; an effect associated with cue repetition, a learning-to-learn effect and a warm-up effect. In most studies these effects are confounded because of the lack of proper control groups. The importance of such controls was emphasized by our results. Using error scores as a measure of rate of learning, the greatest transfer effect was that attributed to warm-up. The next largest was a learning-to-learn effect. After both warm-up and learning-to-learn effects were eliminated no significant effect was found for cue repetition.

Our second major objective was to evaluate the usefulness of single-trial criterialities as indicators of the mediational processes of Ss. These single-trial criterialities proved to be useful in interpreting results. Moreover, they demonstrated the presence of cue-similarity effects not detectable in the error scores. Several other situations where single-trial criterialities would be useful were discussed.

# CHAPTER V

## SUMMARY

The first objective of this experimental study was to identify and compare three kinds of transfer effects: an effect associated with cue repetition, a learning-to-learn effect, and a warm-up effect. The second major objective was to evaluate the usefulness of cue-response criterialities in explaining transfer effects.

A factorial design was employed with three degrees of similarity between the relevant cues for the training tasks and those for the criterion task and two degrees of similarity between type of training task and criterion task.

Conditions of Cue Similarity. For one third of the experimental Ss relevant and irrelevant cues remained the same for all tasks; for another third relevant and irrelevant cues were reversed on the criterion task; and for the remaining third completely new cues were introduced during the criterion task.

Conditions of Task Similarity. For half of the experimental Ss training and criterion tasks were of the same type. For the other half training tasks and criterion tasks were quite different.

In addition to the six experimental groups necessary for the experimental design an additional group of Ss was a control group who performed only the criterion task.

The entire experiment was carried out twice--once using large group testing procedures and once testing groups of either 7 or 14 at a time.

The Ss for this experiment were undergraduate college students. For the first experiment in which large group testing procedures were used the Ss participated in the experiment as part of a course requirement either in introductory psychology or in educational psychology. For the second experiment all Ss volunteered.

The results of the study may be summarized as follows:

1. Ss of the three cue conditions did not differ significantly on the number of errors made during the completion of the criterion task.

2. A learning-to-learn effect was identified. Ss who received training on a series of training tasks similar to the criterion task completed the criterion task with fewer errors than Ss for whom training tasks were unlike the criterion task.

3. A warm-up effect was identified. Subjects who performed a series of four tasks quite different from the criterion task, using cues unlike those used on the criterion task, completed the criterion task with fewer errors than Ss in the control group.

4. Using the same two cues in the solution of a number of training tasks increased the use of these cues on the first trial of the criterion task. The criterialities (correlations between cues and responses) were higher on the first trial of the criterion task for cues that had previously been relevant than for cues that had been irrelevant.

BIBLIOGRAPHY


Adams, J. A. The second facit of forgetting: A review of warm-up decrement. Psychol. Bull. 1961, 58, 257-273.

Adams, J. A. Multiple versus single problem training in human problem solving. J. exp. Psychol., 1954, 48, 15-18.

Adams, J. K. Laboratory studies of behavior without awareness. Psychol. Bull., 1957, 54, 383-405.

Azuma, H. Comparison of a correlational with a probabilistic approach to concept learning. Unpublished doctoral dissertation, University of Illinois, 1960.

Bartlett, M. S. Some examples of statistical methods of research in agriculture and applied biology. J. R. Statist. Soc. Suppl., 1937, 4, 137-170.

Bruce, R. W. Conditions of transfer of training. J. exp. Psychol., 133, 16, 343-361.

Bruner, J. S., Goodnow, J. J., and Austin, G. A. A study of thinking. New York: Wiley, 1956.

Brunswik, E. Perception and the representative design of psychological experiments. Berkeley, Calif.: University of California Press, 1956.

Brunswik, E. and Reiter, L. Eindruckscharaktere schematisierter gesichter. J. Psychol., 1938, 142, 67-134.

Cox, J. W. Some experiments on formal training on the acquisition of skills. Brit. J. Psychol., 1933, 24, 67-87.

Cronbach, L. J. Educational Psychology. N. Y.: Harcourt, 1963.

Cronbach, L. J. and Azuma, H. Can we tell what the learner is thinking from his behavior? Paper presented at the Conference on Research Methodology in Training, Washington University, St. Louis, Missouri, 1961. (a)

Cronbach, L. J. and Azuma, H. Performance on a concept-attainment task with scaled cues. Urbana, Illinois: University of Illinois, 1961. (Mimeo) (b)

D'Amato, M. R. and Jagoda, H. Transfer of brightness discrimination from bar pressing to a Y maze. Psychol. Rep., 1960, 7, 83-90.

Davis, K. G., and Hess, H. F. The effectiveness of concepts at various levels of awareness. J. exp. Psychol., 1962, 63, 62-67.

Duncan, C. P. Description of learning how to learn in human subjects. Amer. J. Psychol., 1960, 73, 108-114.

Duncan, C. P. Transfer after training with single versus multiple tasks. J. exp. Psychol., 1958, 55, 63-72.

Eckstrand, G. A. and Wickens, D. D. Transfer of perceptual set. J. exp. Psychol., 1954, 47, 274-278.

Hamilton, C. E. The relationship between length of interval separating two learning tasks and performance on the second task. J. exp. Psychol., 1950, 40, 613-621.

Harlow, H. T. The formation of learning sets. Psychol. Rev., 1949, 56, 51-65.

Harlow, H. T., Harlow, M. K., Rueping, R. R., and Mason, W. A. Performance of infant rhesus monkeys on discrimination learning, delayed response, and discrimination learning set. J. comp. physiol. Psychol., 1960, 53, 113-121.

Harrow, M. and Friedman, G. B. Comparing reversal and nonreversal shifts in concept formation with partial reinforcement controlled. J. exp. Psychol., 1958, 55, 592-598.

Hull, C. L. Quantitative aspects of the evolution of concepts. Psychol. Monogr., 1920, 28, Whole No. 123.

Hunt, E. B. Concept Learning, N. Y.: Wiley, 1962.

Irion, A. L. The relationship of "set" to retention. Psychol. Rev., 1948, 55, 336-341.

Kelleher, R. T. Discrimination learning as a function of reversal and nonreversal shifts. J. exp. Psychol., 1956, 51, 379-384.

Kendler, H. H. and D'Amato, M. F. A comparison of reversal shifts and nonreversal shifts in human concept formation. J. exp. Psychol., 1955, 49, 165-174.

Kendler, H. H. and Kendler, T. S. Reversal and nonreversal shifts in kindergarten children. J. exp. Psychol., 1959, 58, 56-60.

Lawrence, D. H. Acquired distinctiveness of cues: I. Transfer between discriminations on the basis of familiarity with the stimulus. J. exp. Psychol., 1949, 39, 770-784.

Lawrence D. H. Acquired distinctiveness of cues: II. Selective association in a constant stimulus situation. J. exp. Psychol., 1950, 40, 175-188.

Mandler, G. The warm-up effect: Some further evidence on temporal and task factors. J. exp. Psychol., 1956, 55, 3-8.

Mandler, G. From association to structure. Psychol. Rev., 1962, 69, 415-427.

McHale, T. J. and Stolurow, L. M. Concept formation with metrically multi-valued cues and response categories. Urbana, Illinois: Training Research Laboratory, Tech. Rep. No. 3, ONR Proj., April, 1962.

Shepard, W. O. Learning set in preschool children. J. comp. physio. Psychol., 1957, 50, 15-17.

Smedslund, J. Multiple-probability learning: An inquiry into the origins of perception. Oslo, Norway: Akademisk, 1955.

Smoke, K. L. An objective study of concept formation. Psychol. Monogr., 1932, 42, Whole No. 191.

Stolurow, L. M., Solley, C. M., and Fisher, W. Problem solving in relation to prior probability learning. Urbana, Illinois: Memo. C-27 Task C, A. F. Proj., August 1955.

Thune, L. E. Warm-up effect as a function of level of practice in verbal learning. J. exp. Psychol., 1951, 42, 250-256.

Thune, L. E. The effect of different types of preliminary activities on subsequent learning of paired-associate material. J. exp. Psychol., 1950, 40, 423-438.

Thune, L. E. and Ericksen, S. C. Studies in abstraction learning: IV. The transfer effects of conceptual vs. rote instruction in a simulated classroom situation. Nashville: Vanderbilt Univ., 1960. (Mimeo)

Walk, R. D. Effect of discrimination reversal on human discrimination learning. J. exp. Psychol., 1952, 44, 410-419.

Walker, H. M., and Lev, J. Statistical Inference, New York: Holt, 1953.

Ward, L. B. Reminiscence and rote learning. Psychol. Monogr., 1937, 49, No. 220.

# APPENDIX A

## Order of Stimulus Cues for the Displays of Each Block

## (16 Displays Per Block)

| Display # | 1st Figure | 2nd Figure | 3rd Figure | 4th Figure |
|---|---|---|---|---|
| 1. | rhombus[a] | circle | square | triangle |
| 2. | square | circle | triangle | rhombus |
| 3. | rhombus | square | circle | triangle |
| 4. | circle | square | rhombus | triangle |
| 5. | triangle | rhombus | circle | square |
| 6. | square | rhombus | circle | triangle |
| 7. | circle | triangle | rhombus | square |
| 8. | triangle | square | circle | rhombus |
| 9. | square | rhombus | triangle | circle |
| 10. | circle | rhombus | triangle | square |
| 11. | triangle | rhombus | square | circle |
| 12. | rhombus | triangle | square | circle |
| 13. | triangle | circle | square | rhombus |
| 14. | circle | triangle | square | rhombus |
| 15. | circle | rhombus | square | triangle |
| 16. | rhombus | circle | triangle | square |

[a]When the set of chemistry figures were used the following substitutions were made:
beaker - circle
funnel - square
flask - triangle
jar - rhombus

# APPENDIX B

## Description of Displays Used for Type X Tasks

| Display # | 1st Relevant Cue | 2nd Relevant Cue | 1st Irrelevant Cue | 2nd Irrelevant Cue |
|---|---|---|---|---|
| 1. | -[a] | - | X | X |
| 2. | - | - | - | - |
| 3. | X | - | - | X |
| 4. | X | X | X | - |
| 5. | X | - | X | - |
| 6. | - | X | - | - |
| 7. | - | - | - | X |
| 8. | - | - | X | - |
| 9. | X | X | X | X |
| 10. | X | - | - | - |
| 11. | X | - | X | X |
| 12. | - | X | - | X |
| 13. | X | X | - | X |
| 14. | - | X | X | X |
| 15. | - | X | X | - |
| 16. | X | X | - | - |
| 17. | - | X | X | - |
| 18. | X | X | - | - |
| 19. | - | - | - | - |
| 20. | - | - | - | X |
| 21. | - | X | - | - |
| 22. | X | - | X | - |
| 23. | X | X | X | X |
| 24. | X | - | X | X |
| 25. | - | X | - | X |
| 26. | X | - | - | X |
| 27. | X | - | - | - |
| 28. | - | - | X | - |
| 29. | X | X | - | X |
| 30. | - | - | X | X |
| 31. | - | X | X | X |
| 32. | X | X | X | - |
| 33. | - | X | X | - |
| 34. | X | X | - | - |
| 35. | - | - | - | - |
| 36. | X | - | - | X |
| 37. | X | - | - | - |
| 38. | - | - | X | - |
| 39. | X | X | X | - |
| 40. | X | - | X | - |

[a] X means figure contained an X; "-" means figure was empty.

APPENDIX B (Continued)

| Display # | 1st Relevant Cue | 2nd Relevant Cue | 1st Irrelevant Cue | 2nd Irrelevant Cue |
|---|---|---|---|---|
| 41. | - | - | - | X |
| 42. | - | X | X | X |
| 43. | X | X | - | X |
| 44. | X | X | X | X |
| 45. | - | X | - | X |
| 46. | - | - | X | X |
| 47. | - | X | - | - |
| 48. | X | - | X | X |
| 49. | X | - | X | - |
| 50. | - | X | X | - |
| 51. | X | X | - | - |
| 52. | X | X | X | - |
| 53. | X | X | X | X |
| 54. | X | - | X | X |
| 55. | - | - | X | X |
| 56. | - | - | - | - |
| 57. | X | - | - | X |
| 58. | - | X | X | X |
| 59. | - | - | - | X |
| 60. | - | - | X | - |
| 61. | - | X | - | X |
| 62. | X | X | - | X |
| 63. | - | X | - | - |
| 64. | X | - | - | - |
| 65. | - | - | X | X |
| 66. | - | - | - | X |
| 67. | X | X | X | - |
| 68. | X | - | X | - |
| 69. | - | - | - | - |
| 70. | X | - | - | X |
| 71. | - | X | X | X |
| 72. | - | X | X | - |
| 73. | - | - | X | - |
| 74. | - | X | - | X |
| 75. | X | X | - | X |
| 76. | X | - | X | X |
| 77. | X | X | - | - |
| 78. | - | X | - | - |
| 79. | X | - | - | - |
| 80. | X | X | X | X |

# APPENDIX C

## Instructions to Ss

The written instructions to the Ss varied for the two types of training tasks. The first set of instructions (labeled Appendix C-1) were used for W groups and the second set of instructions (labeled Appendix C-2) were used for X groups. A sheet of sample figures with their correct answers was included in each set of initial instructions. Following each set of initial instructions are the instructions which were given at the beginning of each of the subsequent tasks. New sample figures and their correct answers were also given at the beginning of each subsequent task. Since these sample sheets have been described in the main body of this report they do not appear here.

Control group Ss were given the instructions which appear in Appendix C-1.

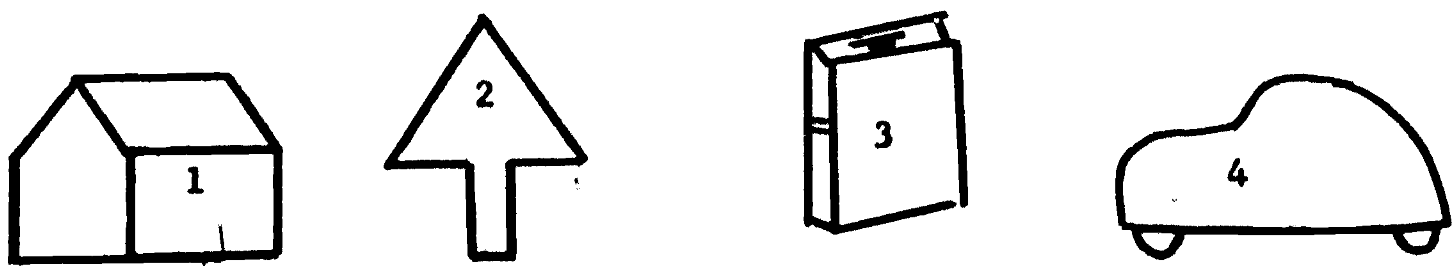
## APPENDIX C-1
## Instructions

(a) Please read these instructions carefully before beginning this problem. On all white sheets you are to look at frames in alphabetical order by beginning at the top frame on each page and proceeding to the bottom frame before turning to the next page.

Go to frame (b)

(b) This booklet contains a problem in which you are to learn to evaluate something called K-ness. You will see a series of figures each containing four shapes. Inside of each shape will be a number from one to four. Frame (c) contains a sample figure.

(c)




Sample Figure 1

(d) Your problem is to learn to estimate K for each figure. I will tell you two things about how K is determined. First, K is affected only by the numbers inside two of the four shapes. One of your tasks is therefore going to be to try to discover which two of the four shapes are relevant in determining K.

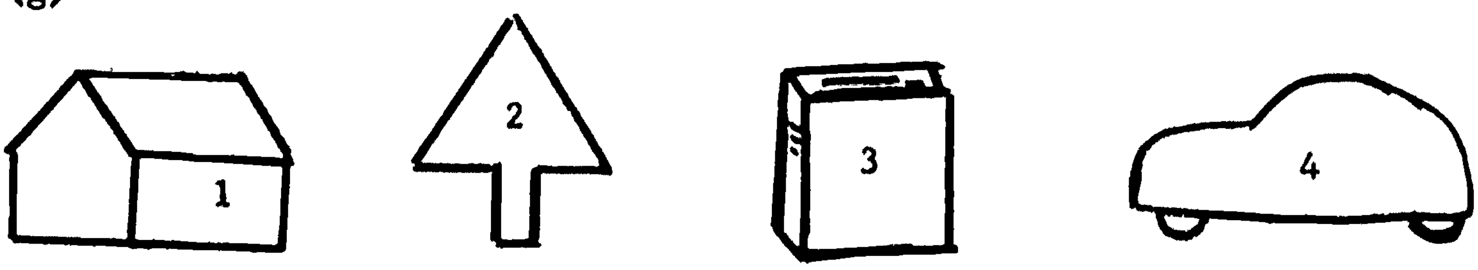
(e)

The second thing I will tell you about K is that K is always obtained by multiplying the numbers inside each of the relevant shapes by some constant and then adding. The numbers inside the two relevant shapes may or may not be multiplied by the same constant. Your second tasks is therefore to discover what constant to multiply each of the relevant shapes by.

Turn to frame (f) on page 2

(f) To make these instructions clear I am going to give you an example. In this example the rule for determining K will be to multiply the number inside the house by four and the number inside the book by two before adding. Look at frames (g), (h), and (i).

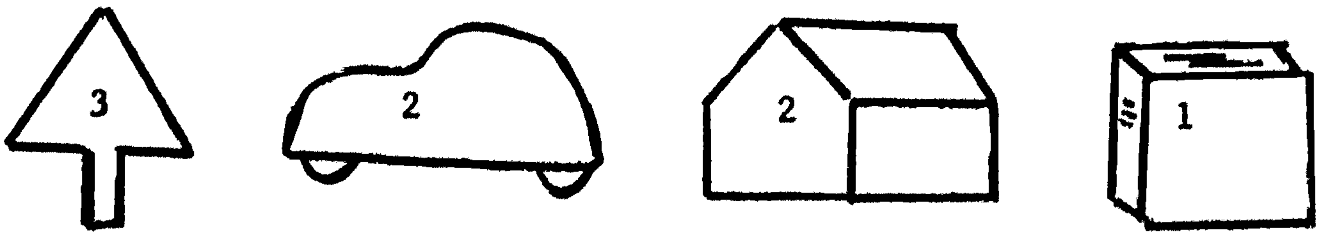
(g)




$K = 4 \times 1 + 2 \times 3$

$K = 4 + 6 = 10$

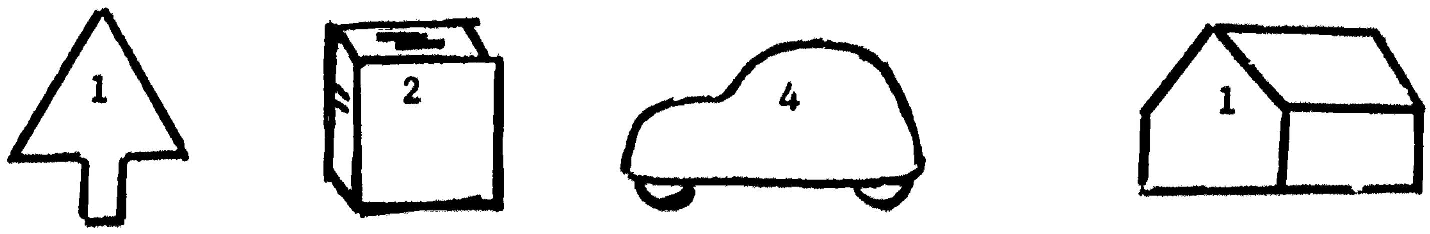
(h)




$K = 4 \times 2 + 2 \times 1$

$K = 8 + 2 = 10$

(i)




$K = 4 \times 1 + 2 \times 2$

$K = 4 + 4 = 8$

(j) In this example K was affected only by the numbers inside two figures; the house and the book. The number inside the house was always multiplied by the constant four and the number inside the book was always multiplied by the constant 2.

Go to Page 3 for frame (k)

(k) All of the pages following the next one will be blue pages containing problem figures. You are to look at only the top figure on each page before turning to the next page. When you get to the last blue page you are then to return to the first blue page and look at the second figure on each page. Do not be alarmed that the figures do not appear in correct numerical sequence. Rather they will appear in the same sequence as the numbers on your answer sheet.

---

(l) You are to look at each figure and then write in your estimate of K in the space opposite the appropriate figure number on the answer sheet. You are then to lift the blue tab on the left side of the booklet in order to see the correct K value. Your first estimates will necessarily be strictly guesses. Later you will learn to predict K correctly for each figure.

---

(m) When you get an answer correct put a large "C" by that answer. When you get 16 correct answers in a row you are to stop and write at the bottom of the answer sheet in the space provided the method which you are using to obtain K. You will then be through with this problem.

---

(n) You will be allowed to spend approximately twenty seconds on each figure. You should write in your answers near the beginning of this twenty second period so that you can see the correct answer while there is still some time remaining to study the figure. A bell will ring every twenty seconds indicating it is time to turn to the next figure. When you are making correct answers regularly you need not wait for the bell to ring before proceeding to the next figure.

---

(o) The next page contains four sample figures and their K values. These sample figures will give you some idea of the range of K for the figures in this problem. Spend about twenty seconds studying each of these sample figures. When you finish looking at the sample figures go to the first blue page of problem figures. Be sure that you answer only one frame on each page before going to the next page. Also be sure that you answer only one frame on each page before going to the next page. Also be sure that you write your answer on the line corresponding to the figure you are studying.

## SAMPLE FIGURES FOR TASK 1

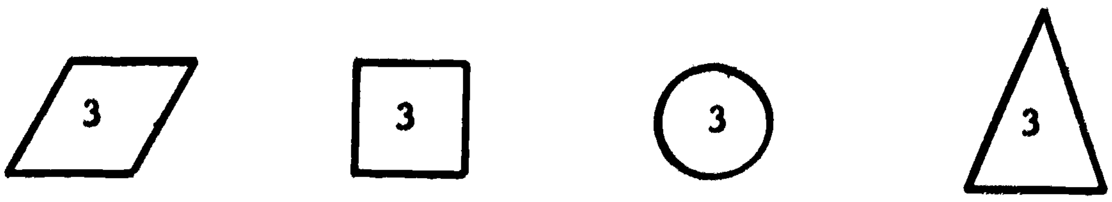
SAMPLE FIG. 1[a]


K = 2

SAMPLE FIG. 2

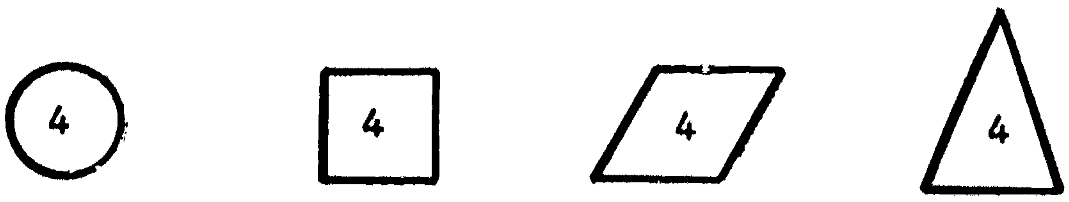

K = 4

SAMPLE FIG. 3




K = 6

SAMPLE FIG. 4




K = 8

For this TASK, K will not be greater than 8 or less than 2.

[a]For new cue groups the appropriate chemistry symbols were used as figures.

## Instructions

In this new problem K is determined a little differently. Again only two shapes are relevant and K is obtained by multiplying the numbers inside each of the two relevant shapes by some constant. Follow the same procedure as for the previous task.

## APPENDIX C-2
## Instructions

(a) Please read these instructions carefully before beginning this problem. On all white sheets you are to look at frames in alphabetical order by beginning at the top frame on each page and proceeding to the bottom frame before turning to the next page.

Go to frame (b)

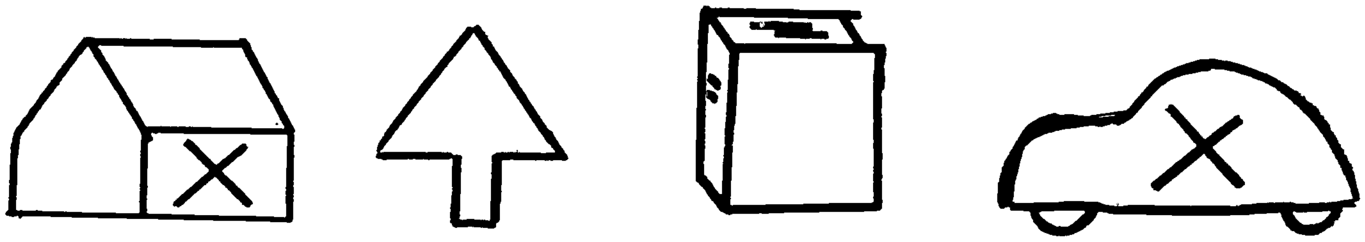
---

(b)

This booklet contains a problem in which you are to learn to evaluate something called "K". You will see a series of figures each containing four shapes. Each shape will either contain an "X" or it will be empty. Frame (c) contains a sample figure.

---

(c)



Sample Figure 1

---

(d)

Your problem is to learn to judge whether each figure is a K figure or not. I will give you a hint. Although there are four shapes in each figure, only two shapes influence whether a figure is a K figure or not. For example, suppose only the house and the book are relevant in determining whether a figure is a K figure or not. This means that you could entirely disregard the car and the tree. One of your tasks for this problem will therefore be to discover which two shapes are relevant.

---

(e)

Your second task will be to discover what it is about these two relevant shapes which determines whether or not the figure is a K figure. Order of shapes will be irrelevant so that the <u>presence</u> or <u>absence</u> of X's in the two relevant shapes must be the basis for classifying figures. It may be that both relevant shapes must be empty, or that both must contain X's, or that one must be empty and the other contain an X.

(f)

All of the pages following the next one will be blue pages containing problem figures. You are to look at only the top figure on each page before turning to the next page. When you get to the last blue page you are then to return to the first blue page and look at the second figure on each page. Do not be alarmed that the figures do not appear in correct numerical sequence. Rather they will appear in the same sequence as the numbers on your answer sheet.

---

(g)

You are to look at each figure and then guess whether or not the figure is a K figure. If you think the figure is a K figure write a K on the space opposite the appropriate figure number on the answer sheet. If you do not believe the figure is a K figure make an 0 on your answer sheet. Your first answers will be strictly guesses. Later you will learn to classify each figure correctly. In order to find the correct answer for each figure lift the blue tab on the left side of the booklet.

---

(h)

When you get an answer correct put a large "C" by that answer. When you get 16 correct answers in a row you are to stop and write at the bottom of the answer sheet in the space provided a description of how a K card is defined. You will then be through with this problem.

---

(i)

You will be allowed to spend approximately twenty seconds on each figure. You should write in your answers near the beginning of this twenty second period so that you can see the correct answer while there is still some time remaining to study the figure. A bell will ring every twenty seconds indicating it is time to turn to the next figure. When you are making correct answers regularly you need not wait for the bell to ring before proceeding to the next figure.

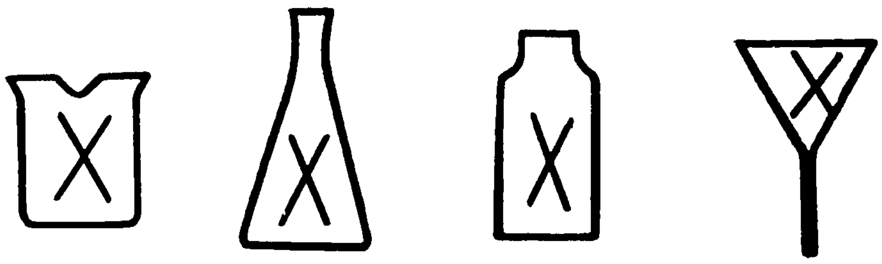
---

(j)

The next page contains two sample figures and their correct answers. These sample figures will give you some idea of how a K card is defined in this problem. Spend about twenty seconds studying each of the sample figures. When you finish looking at the sample figures go to the first blue page of problem figures. Be sure that you answer only one frame on each page before going to the next page. Also be sure that you write your answer on the line corresponding to the figure you are studying.

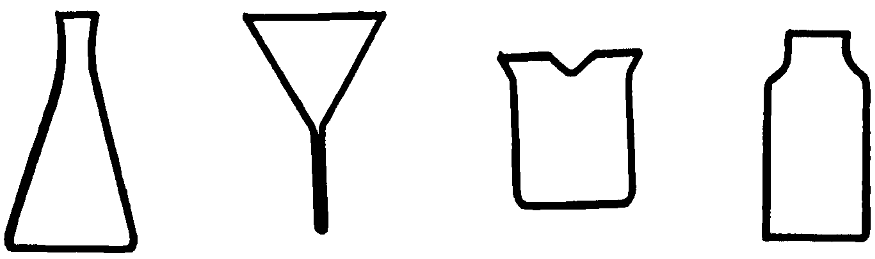
## SAMPLE FIGURES FOR TASK 1

SAMPLE FIGURE 1[a]



Answer K

SAMPLE FIGURE 2



Answer O

[a]For same cue groups and opposite cue groups the appropriate geometric figures were used.

## Instructions

In this new problem a K figure is defined a little differently. Again only two shapes are relevant and it is the presence or absence of X's in these relevant shapes that determines whether a figure is a K figure. Follow the same procedure as for the previous task.

## Instructions

(a)

Now you are going to be asked to solve a task which is of a different type from those which you have been solving. You will, however, discover some similarities.

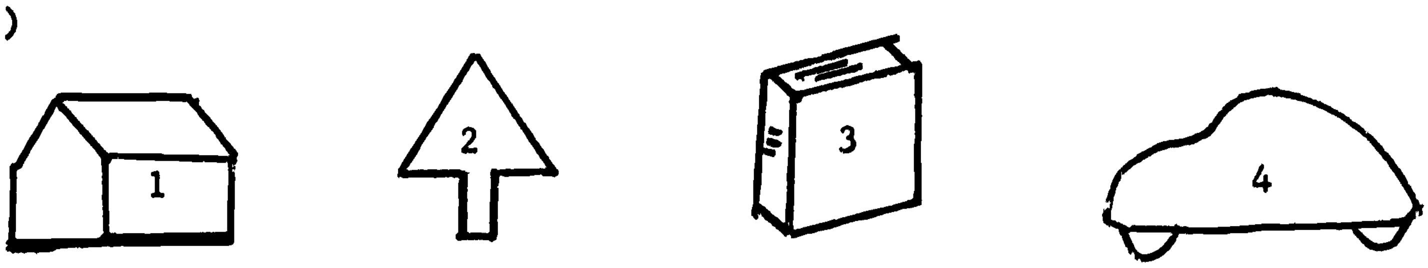
---

(b)

In this problem you are going to learn to evaluate something called K-ness. You will se a series of displays each containing four shapes. Inside each shape will be a number from one to four. Frame (c) contains a sample figure.

---

(c)




Sample Figure 1

---

(d)

Your problem is to learn to estimate K for each figure. I will tell you two things about how K is determined. First, K is affected only by the numbers inside two of the four shapes. One of your tasks is therefore going to be to try to discover which two of the four shapes are relevant in determining K.

---

(e)

The second thing I will tell you about K is that K is always obtained by multiplying the numbers inside each of the relevant shapes by some constant and then adding. The numbers inside the two relevant shapes may or may not be multiplied by the same constant. Your second task is therefore to discover what constant to multiply each of the relevant shapes by.

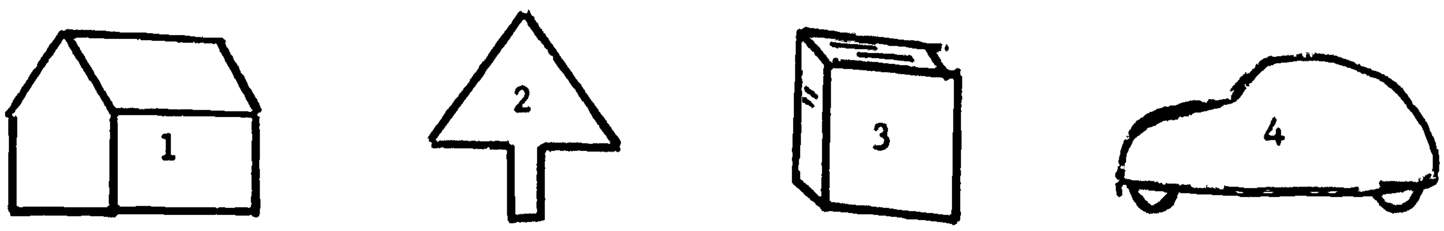
Turn to frame (f) on page 2

(f)

To make these instructions clear I am going to give you an example. In this example the rule for determining K will be to multiply the number inside the house by four and the number inside the book by two before adding. Look at frames (g), (h), and (i).

---

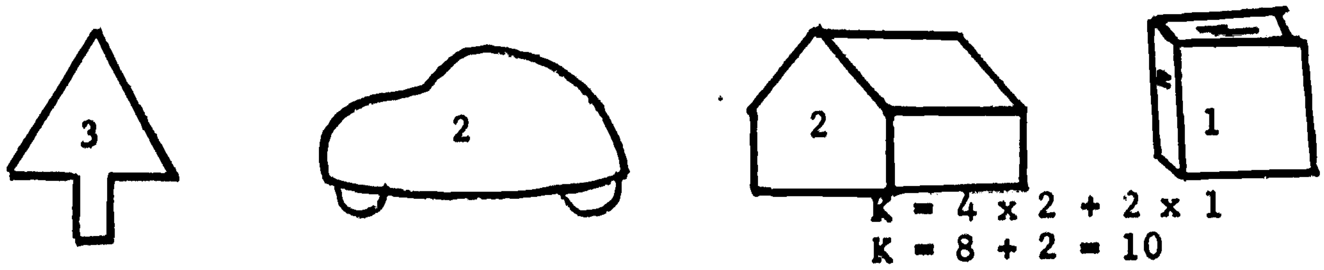
(g)




$K = 4 \times 1 + 2 \times 3$
$K = 4 + 6 = 10$

---

(h)




$K = 4 \times 2 + 2 \times 1$
$K = 8 + 2 = 10$

---

(i)


$K = 4 \times 1 + 2 \times 2$
$K = 4 + 4 = 8$

---

(j)

In this example K was affected only by the numbers inside two figures: the house and the book. The number inside the house was always multiplied by the constant four and the number inside the book was always multiplied by the constant 2.

Go to Page 3 for frame (k)

(k)

You are to follow the same general procedure for this task as for earlier tasks. For this task your answers will be numbers rather than K's and O's. Again you will have twenty seconds for each display. Answers will again be found under the blue tabs at the left side of the booklet. Mark correct answers with a "C" then when you get 16 correct answers in a row write the formula for determining K in the space provided at the bottom of the answer sheet.

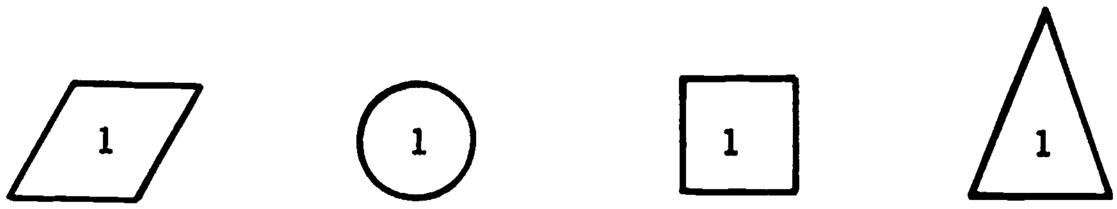
---

(l)

The next page contains four sample figures and their K values. These sample figures will give you some idea of the range of K for the figures in this problem. Spend about twenty seconds studying each of these sample figures. When you finish looking at the sample figures go to the first blue page of problem figures. Be sure that you answer only one frame on each page before going to the next page. Also be sure that you write your answer on the line corresponding to the figure you are studying.

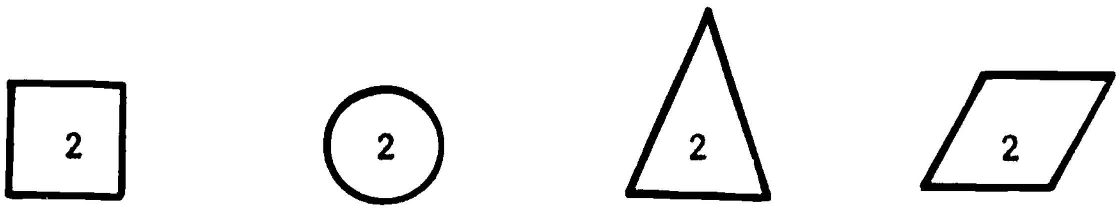
## SAMPLE FIGURES FOR TASK 5

SAMPLE FIG. 1




K = 1½

SAMPLE FIG. 2

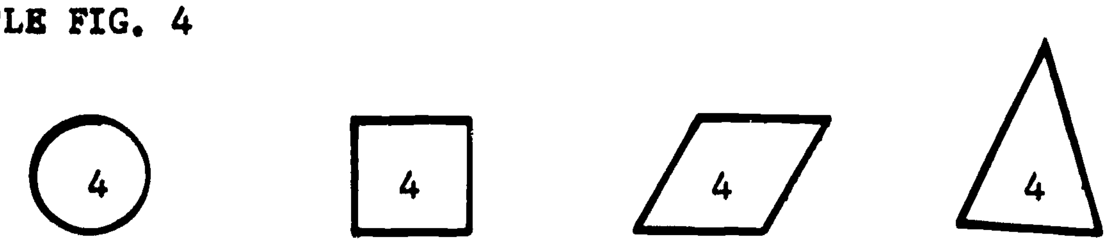



K = 3

SAMPLE FIG. 3


K = 4½

SAMPLE FIG. 4




K = 6

For this TASK, K will not be greater than 6 or less than 1½.

# APPENDIX D

## Error Scores for Each S by Group

### Group WS

| S# | Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criter-ion task | Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criter-ion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | 16 | 15 | 5 | 49 | 10 | 10 | 23 | 5 | 4 | 42 | 12 |
| 2 | 18 | 59 | 57 | 12 | 146 | 5 | 13 | 1 | 1 | 2 | 17 | 2 |
| 3 | 7 | 19 | 14 | 7 | 47 | 0 | 1 | 11 | 1 | 1 | 14 | 1 |
| 4 | 3 | 5 | 11 | 1 | 20 | 16* | 4 | 4 | 2 | 2 | 12 | 4 |
| 5 | 2 | 9 | 9 | 3 | 23 | 3* | 20 | 6 | 7 | 24 | 57 | 21 |
| 6 | 2 | 1 | 5 | 6 | 14 | 3 | 9 | 2 | 15 | 9 | 35 | 2 |
| 7 | 4 | 24 | 50 | 6 | 84 | 12 | 3 | 26 | 21 | 11 | 61 | 2 |
| 8 | 39 | 0 | 8 | 5 | 52 | 0* | 2 | 8 | 17 | 1 | 28 | 41* |
| 9 | 1 | 6 | 13 | 4 | 24 | 1 | 42 | 6 | 32 | 2 | 82 | 2 |
| 10 | 6 | 0 | 2 | 0 | 8 | 0 | 6 | 21 | 2 | 5 | 34 | 11 |
| 11 | 25 | 20 | 3 | 1 | 49 | 2 | 2 | 2 | 1 | 1 | 6 | 3 |
| 12 | 11 | 56 | 61 | 14 | 142 | 5 | 7 | 5 | 2 | 1 | 15 | 0 |
| 13 | 6 | 10 | 31 | 7 | 54 | 27 | 5 | 9 | 1 | 3 | 18 | 4 |
| 14 | 6 | 1 | 13 | 10 | 30 | 4 | 2 | 3 | 2 | 1 | 8 | 0 |
| 15 | 16 | 15 | 1 | 5 | 37 | 2 | 65 | 10 | 2 | 26 | 103 | 1 |
| 16 | 1 | 1 | 70 | 1 | 73 | 5 | 4 | 2 | 4 | 10 | 20 | 6 |
| Med. | .6.17 | 9.50 | 13.00 | 5.17 | 48.00 | 3.50 | 5.50 | 6.00 | 2.30 | 2.50 | 24.00 | 2.50 |
| Mean | 10.00 | 15.12 | 22.68 | 5.44 | 53.25 | 5.94 | 12.19 | 8.69 | 7.19 | 6.44 | 34.50 | 7.00 |
| S.D. | 10.35 | 18.29 | 23,3 | 3.99 | 40.96 | 7.09 | 17.37 | 7.91 | 9.19 | 7,99 | 28.12 | 10.64 |

*The S originally scheduled to be a member of this group had to be eliminated either because he failed to follow directions or because he failed to complete the training tasks. Data reported is for a second S.

APPENDIX D (Continued)

Group WO

| | Experiment I | | | | | | Experiment II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S# | Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criter-ion Task | Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criter-ion |
| 1 | 50 | 13 | 63 | 8 | 134 | 6 | 16 | 7 | 2 | 3 | 28 | 8 |
| 2 | 3 | 46 | 53 | 2 | 104 | 0 | 3 | 3 | 3 | 3 | 12 | 2 |
| 3 | 6 | 4 | 12 | 16 | 38 | 11 | 5 | 2 | 7 | 2 | 16 | 4 |
| 4 | 18 | 0 | 3 | 3 | 24 | 11 | 17 | 4 | 3 | 7 | 31 | 9 |
| 5 | 12 | 2 | 1 | 13 | 28 | 5 | 11 | 3 | 34 | 13 | 61 | 9 |
| 6 | 10 | 13 | 2 | 72 | 97 | 5 | 7 | 18 | 47 | 5 | 77 | 7 |
| 7 | 4 | 2 | 1 | 22 | 29 | 7 | 2 | 15 | 20 | 8 | 45 | 8* |
| 8 | 20 | 6 | 3 | 2 | 31 | 7* | 18 | 0 | 0 | 17 | 35 | 20 |
| 9 | 8 | 7 | 7 | 4 | 26 | 2* | 3 | 3 | 2 | 4 | 12 | 3 |
| 10 | 7 | 17 | 6 | 2 | 32 | 1 | 9 | 6 | 48 | 2 | 65 | 11 |
| 11 | 48 | 17 | 5 | 1 | 71 | 8 | 12 | 13 | 9 | 2 | 36 | 2 |
| 12 | 9 | 3 | 16 | 9 | 37 | 0* | 7 | 3 | 0 | 1 | 11 | 4 |
| 13 | 4 | 1 | 1 | 2 | 8 | 2 | 4 | 7 | 2 | 7 | 20 | 4 |
| 14 | 0 | 1 | 0 | 1 | 2 | 3 | 5 | 1 | 7 | 2 | 15 | 10 |
| 15 | 7 | 6 | 1 | 5 | 19 | 2 | 13 | 0 | 14 | 17 | 44 | 5 |
| 16 | 6 | 1 | 8 | 2 | 17 | 11 | 14 | 7 | 7 | 20 | 48 | 2 |
| Med. | 7.5 | 5.0 | 4.0 | 3.5 | 30.0 | 4.00 | 8.0 | 3.5 | 6.83 | 4.50 | 33.0 | 6.00 |
| Mean | 13.25 | 8.69 | 11.38 | 10.25 | 43.56 | 5.06 | 9.12 | 5.75 | 12.81 | 7.06 | 34.75 | 6.75 |
| S.D. | 14.88 | 11.49 | 18.81 | 17.57 | 37.64 | 3.86 | 5.37 | 5.35 | 16.12 | 6.25 | 20.62 | 4.67 |

# APPENDIX D (Continued)

## Group WN

| S# | Experiment I Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion Task | Experiment II Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 2 | 5 | 12 | 4 | 47 | 30 | 18 | 0 | 95 | 1 |
| 2 | 4 | 0 | 8 | 1 | 13 | 3 | 5 | 12 | 7 | 5 | 29 | 2 |
| 3 | 27 | 19 | 7 | 1 | 54 | 7 | 2 | 6 | 68 | 2 | 78 | 3 |
| 4 | 34 | 3 | 71 | 11 | 119 | 1 | 1 | 26 | 14 | 19 | 60 | 2 |
| 5 | 40 | 3 | 17 | 8 | 68 | 10 | 8 | 3 | 6 | 4 | 21 | 0 |
| 6 | 3 | 17 | 3 | 7 | 30 | 1 | 10 | 13 | 0 | 10 | 33 | 5 |
| 7 | 1 | 1 | 1 | 5 | 8 | 1 | 10 | 2 | 24 | 8 | 44 | 1 |
| 8 | 3 | 1 | 0 | 1 | 5 | 16 | 7 | 1 | 4 | 46 | 58 | 17 |
| 9 | 1 | 1 | 5 | 7 | 14 | 3 | 10 | 12 | 15 | 15 | 52 | 2 |
| 10 | 26 | 6 | 6 | 5 | 43 | 13 | 4 | 4 | 4 | 4 | 16 | 4 |
| 11 | 15 | 4 | 8 | 0 | 27 | 1 | 52 | 4 | 19 | 9 | 84 | 0 |
| 12 | 1 | 2 | 11 | 1 | 15 | 2 | 1 | 3 | 3 | 2 | 9 | 4 |
| 13 | 37 | 0 | 0 | 2 | 39 | 3 | 47 | 21 | 0 | 4 | 72 | 1 |
| 14 | 3 | 2 | 3 | 1 | 9 | 1 | 1 | 2 | 9 | 6 | 18 | 2 |
| 15 | 9 | 15 | 2 | 9 | 35 | 1 | 47 | 4 | 3 | 6 | 60 | 28 |
| 16 | 11 | 6 | 2 | 3 | 22 | 3 | 4 | 1 | 0 | 4 | 9 | 6 |
| Med. | 6.5 | 2.5 | 4.0 | 4.0 | 24.5 | 2.75 | 9.83 | 3.83 | 6.5 | 5.5 | 59.0 | 2.25 |
| Mean | 13.56 | 5.19 | 9.12 | 4.19 | 32.06 | 4.38 | 16.00 | 9.00 | 12.12 | 9.00 | 46.12 | 4.87 |
| S.D. | 14.29 | 6.16 | 17.1 | 3.44 | 29.11 | 4.68 | 19.51 | 9.27 | 16.67 | 11.01 | 27.84 | 7.37 |

APPENDIX D (Continued)

Group XS

| S# | Experiment I Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion Task | Experiment II Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12 | 8 | 17 | 3 | 40 | 14 | 22 | 1 | 2 | 7 | 32 | 6 |
| 2 | 33 | 21 | 24 | 5 | 83 | 24 | 3 | 4 | 1 | 3 | 11 | 3 |
| 3 | 7 | 7 | 9 | 8 | 31 | 14 | 2 | 6 | 68 | 2 | 78 | 3 |
| 4 | 8 | 3 | 7 | 3 | 21 | 17 | 4 | 2 | 4 | 2 | 12 | 2 |
| 5 | 23 | 33 | 6 | 10 | 72 | 4 | 15 | 1 | 13 | 16 | 45 | 12 |
| 6 | 6 | 18 | 8 | 2 | 34 | 18 | 26 | 4 | 1 | 6 | 37 | 2 |
| 7 | 3 | 2 | 2 | 4 | 11 | 1* | 4 | 5 | 1 | 3 | 13 | 4 |
| 8 | 1 | 1 | 0 | 3 | 5 | 3* | 10 | 4 | 8 | 2 | 24 | 7 |
| 9 | 3 | 8 | 1 | 1 | 13 | 3 | 21 | 5 | 6 | 4 | 36 | 15 |
| 10 | 59 | 0 | 17 | 16 | 92 | 16* | 30 | 4 | 6 | 0 | 40 | 6 |
| 11 | 19 | 5 | 7 | 2 | 33 | 4 | 5 | 3 | 1 | 0 | 9 | 1 |
| 12 | 29 | 16 | 8 | 3 | 56 | 25* | 39 | 3 | 14 | 2 | 58 | 5 |
| 13 | 17 | 3 | 5 | 6 | 31 | 3 | 12 | 2 | 1 | 0 | 15 | 10 |
| 14 | 5 | 4 | 1 | 0 | 10 | 2 | 23 | 15 | 11 | 0 | 49 | 11 |
| 15 | 25 | 2 | 23 | 4 | 54 | 6 | 18 | 11 | 2 | 5 | 36 | 15 |
| 16 | 20 | 9 | 2 | 2 | 33 | 4 | 44 | 12 | 10 | 15 | 81 | 1 |
| Med. | 14.5 | 6,0 | 7.0 | 2.75 | 33.0 | 5.00 | 16.5 | 6.17 | 4.0 | 2.5 | 36,0 | 5.50 |
| Mean | 16.88 | 8.75 | 8.56 | 4.50 | 38.69 | 9.88 | 17.38 | 5.12 | 9.31 | 4.19 | 36.00 | 6.43 |
| S.D. | 15.05 | 8.98 | 7.69 | 3.99 | 26.27 | 8.24 | 12.96 | 4.06 | 16.30 | 4.90 | 22.51 | 4.77 |

APPENDIX D (Continued)

Group XO

| | Experiment I | | | | | | Experiment II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S# | Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criter- ion Task | Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criter- ion |
| 1 | 10 | 10 | 24 | 4 | 48 | 22 | 5 | 2 | 2 | 4 | 13 | 2 |
| 2 | 16 | 15 | 2 | 4 | 37 | 7 | 15 | 9 | 1 | 1 | 26 | 2 |
| 3 | 11 | 16 | 21 | 12 | 60 | 3* | 4 | 2 | 2 | 4 | 12 | 3 |
| 4 | 30 | 18 | 12 | 5 | 65 | 1* | 16 | 19 | 9 | 5 | 49 | 17 |
| 5 | 24 | 2 | 4 | 2 | 32 | 1 | 15 | 0 | 14 | 5 | 34 | 6 |
| 6 | 3 | 28 | 3 | 3 | 37 | 5 | 4 | 14 | 4 | 20 | 42 | 1 |
| 7 | 33 | 5 | 3 | 4 | 45 | 4 | 11 | 2 | 7 | 6 | 26 | 23 |
| 8 | 43 | 8 | 12 | 2 | 65 | 14 | 11 | 3 | 1 | 0 | 15 | 8 |
| 9 | 3 | 6 | 4 | 5 | 18 | 10 | 8 | 2 | 1 | 5 | 16 | 1 |
| 10 | 1 | 28 | 37 | 8 | 74 | 9 | 8 | 3 | 0 | 10 | 21 | 20 |
| 11 | 6 | 8 | 18 | 0 | 32 | 0 | 25 | 3 | 1 | 1 | 30 | 4 |
| 12 | 22 | 7 | 19 | 3 | 51 | 7 | 6 | 3 | 6 | 8 | 23 | 1 |
| 13 | 1 | 30 | 12 | 1 | 44 | 2 | 8 | 3 | 1 | 2 | 14 | 1 |
| 14 | 1 | 34 | 7 | 1 | 43 | 1 | 3 | 4 | 6 | 1 | 14 | 5 |
| 15 | 25 | 27 | 26 | 7 | 85 | 74 | 2 | 4 | 3 | 0 | 9 | 3 |
| 16 | 1 | 11 | 7 | 6 | 25 | 38* | 13 | 36 | 2 | 5 | 56 | 5 |
| Med. | 10.5 | 13.0 | 12.17 | 4.17 | 43.5 | 6.00 | 7.83 | 2.90 | 2.17 | 4.5 | 22.0 | 3.50 |
| Mean | 14.38 | 15.81 | 13.19 | 4.19 | 47.56 | 12.38 | 9.62 | 6.81 | 3.75 | 4.81 | 25.00 | 6.37 |
| S.D. | 13.54 | 10.39 | 9.68 | 3.04 | 18.27 | 19.12 | 6.10 | 9.25 | 3.78 | 4.94 | 14.01 | 7.14 |

APPENDIX D (Continued)

Group XN

| S# | Experiment I Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion Task | Experiment II Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14 | 5 | 1 | 1 | 21 | 3 | 18 | 1 | 2 | 7 | 28 | 5 |
| 2 | 5 | 7 | 22 | 12 | 46 | 6 | 11 | 10 | 12 | 2 | 35 | 1 |
| 3 | 26 | 9 | 11 | 3 | 49 | 3 | 12 | 2 | 9 | 7 | 30 | 4 |
| 4 | 21 | 6 | 27 | 1 | 55 | 1 | 1 | 6 | 4 | 2 | 13 | 1 |
| 5 | 19 | 19 | 21 | 12 | 71 | 19 | 19 | 3 | 1 | 5 | 28 | 6 |
| 6 | 14 | 7 | 13 | 1 | 35 | 4 | 52 | 5 | 2 | 2 | 61 | 9 |
| 7 | 44 | 7 | 24 | 6 | 81 | 19 | 9 | 5 | 2 | 6 | 22 | 0 |
| 8 | 16 | 21 | 12 | 9 | 58 | 7 | 8 | 2 | 2 | 2 | 14 | 3 |
| 9 | 16 | 22 | 3 | 6 | 47 | 2 | 19 | 15 | 7 | 6 | 47 | 5 |
| 10 | 11 | 8 | 0 | 2 | 21 | 15* | 9 | 3 | 3 | 0 | 15 | 11 |
| 11 | 26 | 6 | 4 | 10 | 46 | 2 | 24 | 5 | 2 | 3 | 34 | 36 |
| 12 | 7 | 11 | 14 | 2 | 34 | 0 | 11 | 4 | 5 | 1 | 21 | 3 |
| 13 | 7 | 5 | 33 | 2 | 47 | 9 | 2 | 20 | 6 | 7 | 35 | 7 |
| 14 | 12 | 6 | 1 | 0 | 19 | 10 | 7 | 1 | 6 | 4 | 18 | 9 |
| 15 | 32 | 31 | 5 | 6 | 74 | 72 | 23 | 0 | 13 | 3 | 39 | 73 |
| 16 | 2 | 1 | 0 | 0 | 3 | 1 | 14 | 29 | 25 | 4 | 72 | 53 |
| Med. | 15.0 | 6.83 | 12.0 | 2.5 | 46.5 | 5.00 | 11.5 | 4.5 | 4.5 | 3.5 | 29.0 | 5.50 |
| Mean | 17.00 | 10.69 | 11.94 | 4.56 | 44.19 | 10.81 | 14.94 | 6.94 | 6.31 | 3.81 | 32.00 | 14.12 |
| S.D. | 10.91 | 8.13 | 10.71 | 4.23 | 21.46 | 17.46 | 11.96 | 7.96 | 6.18 | 2.29 | 16.66 | 21.13 |

APPENDIX D (Continued)

Control Groups

| S# | Experiment I Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion task | Experiment II Task 1 | Task 2 | Task 3 | Task 4 | Total 1 - 4 | Criterion Task |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | 15 | | | | | | 43 |
| 2 | | | | | | 43 | | | | | | 20 |
| 3 | | | | | | 7 | | | | | | 12 |
| 4 | | | | | | 55 | | | | | | 15 |
| 5 | | | | | | 18 | | | | | | 17 |
| 6 | | | | | | 74 | | | | | | 0 |
| 7 | | | | | | 40 | | | | | | 20 |
| 8 | | | No | | | 20 | | | No | | | 63 |
| 9 | | | | | | 67 | | | | | | 8 |
| 10 | | | Training | | | 14 | | | Training | | | 6 |
| 11 | | | | | | 5 | | | | | | 9 |
| 12 | | | Tasks | | | 68 | | | Tasks | | | 12 |
| 13 | | | | | | 4 | | | | | | 36 |
| 14 | | | | | | 10 | | | | | | 4 |
| 15 | | | | | | 13 | | | | | | 29 |
| 16 | | | | | | 17 | | | | | | 73 |
| Med. | | | | | | 17.50 | | | | | | 16.00 |
| Mean | | | | | | 29.38 | | | | | | 22.94 |
| S.D. | | | | | | 24.57 | | | | | | 21.08 |

## APPENDIX E

### Total Number of Errors by Trial for the First 32 Trials of the Criterion Task

| | Groups | | | | | | |
|---|---|---|---|---|---|---|---|
| Trial | WS | WO | WN | XS | XO | XN | Control |
| 1. | 21[a] | 28 | 20 | 24 | 26 | 25 | 22 |
| 2. | 21 | 27 | 18 | 25 | 22 | 23 | 26 |
| 3. | 12 | 21 | 15 | 23 | 18 | 23 | 24 |
| 4. | 15 | 17 | 12 | 18 | 20 | 17 | 24 |
| 5. | 12 | 14 | 9 | 20 | 19 | 17 | 26 |
| 6. | 11 | 12 | 8 | 17 | 13 | 15 | 23 |
| 7. | 6 | 12 | 6 | 12 | 14 | 16 | 25 |
| 8. | 8 | 13 | 3 | 17 | 13 | 13 | 26 |
| 9. | 6 | 11 | 3 | 13 | 12 | 9 | 21 |
| 10. | 7 | 10 | 4 | 15 | 10 | 10 | 24 |
| 11. | 7 | 6 | 4 | 15 | 9 | 10 | 22 |
| 12. | 6 | 4 | 4 | 9 | 8 | 7 | 24 |
| 13. | 6 | 5 | 5 | 9 | 8 | 7 | 20 |
| 14. | 4 | 3 | 4 | 9 | 9 | 7 | 20 |
| 15. | 3 | 1 | 4 | 10 | 8 | 7 | 18 |
| 16. | 3 | 1 | 2 | 8 | 4 | 8 | 19 |
| 17. | 3 | 1 | 3 | 4 | 5 | 5 | 15 |
| 18. | 3 | 1 | 3 | 4 | 5 | 4 | 17 |
| 19. | 3 | 1 | 2 | 2 | 5 | 5 | 17 |
| 20. | 3 | 1 | 2 | 4 | 4 | 6 | 14 |
| 21. | 4 | 1 | 3 | 3 | 6 | 5 | 14 |
| 22. | 1 | 1 | 2 | 1 | 2 | 5 | 14 |
| 23. | 1 | 0 | 2 | 2 | 4 | 5 | 13 |
| 24. | 3 | 0 | 1 | 2 | 3 | 3 | 12 |
| 25. | 2 | 0 | 1 | 1 | 2 | 4 | 13 |
| 26. | 1 | 0 | 0 | 1 | 3 | 4 | 12 |
| 27. | 0 | 0 | 0 | 1 | 2 | 4 | 13 |
| 28. | 0 | 0 | 1 | 1 | 1 | 4 | 13 |
| 29. | 2 | 0 | 1 | 0 | 2 | 4 | 8 |
| 30. | 2 | 0 | 1 | 0 | 2 | 3 | 11 |
| 31. | 2 | 0 | 1 | 0 | 1 | 3 | 10 |
| 32. | 1 | 0 | 1 | 0 | 2 | 4 | 9 |

[a]Since there were 32 Ss in each group when the two experiments were combined, the maximum number of errors possible for any trial would be 32.

# APPENDIX F

## Percentage of Incorrect Responses for Blocks of Four Trials on the Criterion Task (Figures 4, 5, and 6)

| | Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Trials | W | X | WX | WO | WN | XS | XO | XN | Control |
| 1- 4 | .56 | .69 | .54 | .73 | .51 | .70 | .67 | .69 | .75 |
| 5- 8 | .29 | .46 | .29 | .40 | .20 | .52 | .46 | .48 | .78 |
| 9-12 | .19 | .33 | .20 | .24 | .12 | .39 | 3.0 | .28 | .71 |
| 13-16 | .11 | .25 | .12 | .08 | .12 | .28 | .23 | .23 | .60 |
| 17-20 | .07 | .14 | .09 | .03 | .08 | .11 | .15 | .16 | .49 |
| 21-24 | .05 | .11 | .07 | .02 | .06 | .06 | .12 | .14 | .41 |
| 25-28 | .01 | .07 | .02 | .00 | .02 | .03 | .06 | .12 | .40 |
| 29-32 | .03 | .06 | .05 | .00 | .03 | .00 | .05 | .11 | .30 |

# APPENDIX G

## Single-Trial Cue Criterialities

### Group WS

| Trials | Experiment I 1st Rel | Experiment I 2nd Rel | Experiment I 1st Irr | Experiment I 2nd Irr | Experiment II 1st Rel | Experiment II 2nd Rel | Experiment II 1st Irr | Experiment II 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | .83 | .17 | -.07 | -.10 | .02 | .18 | .00 | .51 |
| 2 | .19 | .31 | -.13 | .29 | .67 | .34 | .20 | -.02 |
| 3 | .19 | .40 | .46 | .11 | .57 | .74 | -.07 | .07 |
| 4 | .36 | .74 | .08 | -.02 | .41 | .41 | .19 | -.30 |
| 5 | .43 | .75 | -.14 | -.09 | .27 | .40 | .05 | .44 |
| 6 | .50 | .36 | -.04 | .16 | .19 | .82 | .12 | .29 |
| 7 | .30 | .82 | -.18 | .11 | .52 | .76 | -.02 | -.16 |
| 8 | .13 | .91 | -.09 | .07 | .36 | .78 | -.25 | -.02 |
| 9 | .32 | .86 | .02 | -.22 | .65 | .71 | .06 | -.04 |
| 10 | .37 | .80 | -.11 | .15 | .47 | .67 | -.03 | .08 |
| 11 | .60 | .73 | .03 | -.10 | .47 | .61 | -.24 | .26 |
| 12 | .45 | .80 | .00 | -.13 | .09 | .55 | .45 | -.07 |
| 13 | .06 | .68 | .48 | .18 | .50 | .82 | .05 | -.08 |
| 14 | .40 | .89 | -.01 | -.05 | .46 | .84 | .04 | -.04 |
| 15 | .62 | .68 | .07 | .09 | .44 | .89 | -.03 | -.01 |
| 16 | .48 | .85 | .10 | -.05 | .42 | .77 | -.18 | .01 |
| 17 | .47 | .86 | .00 | .16 | .34 | .90 | -.04 | .31 |
| 18 | .39 | .90 | -.16 | .15 | .40 | .77 | -.19 | .31 |
| 19 | .26 | .87 | -.24 | .14 | .37 | .84 | .02 | .28 |
| 20 | .55 | .80 | -.12 | .18 | .47 | .86 | -.11 | .28 |
| 21. | .41 | .86 | -.05 | .31 | .50 | .76 | .06 | .07 |
| 22 | .45 | .89 | -.08 | .21 | .42 | .90 | -.05 | .22 |
| 23 | .55 | .80 | .03 | .32 | .45 | .89 | -.08 | .21 |
| 24 | .47 | .88 | -.07 | .22 | .58 | .58 | .11 | .29 |
| 25 | .52 | .82 | -.12 | .10 | .50 | .85 | -.10 | .20 |
| 26 | .45 | .89 | -.10 | .23 | .45 | .89 | -.08 | .21 |
| 27 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 28. | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 29 | .46 | .88 | -.05 | .18 | .46 | .89 | -.07 | .22 |
| 30 | .48 | .85 | -.16 | .20 | .48 | .87 | -.10 | .18 |
| 31 | .41 | .89 | -.06 | .14 | .45 | .89 | -.09 | .22[a] |
| 32 | .50 | .82 | -.05 | .25 | .45 | .89 | -.08 | .21 |
| 33 | .45 | .89 | .02 | -.03 | .45 | .89 | .02 | -.03 |
| 34 | .45 | .89 | .02 | .03 | .46 | .89 | .02 | .04 |
| 35 | .45 | .89 | .02 | -.01 | .45 | .89 | .02 | .00 |
| 36 | .45 | .89 | .02 | -.13 | .45 | .89 | .02 | -.13 |
| 37 | .45 | .89 | .02 | -.07 | .45 | .89 | .03 | -.10 |
| 38 | .45 | .89 | .02 | -.10 | .50 | .85 | .07 | -.04 |
| 39 | .45 | .89 | .02 | -.04 | .45 | .89 | .04 | -.04 |
| 40 | .45 | .89 | .02 | -.12 | .48 | .87 | .03 | -.16 |

[a]Correlations for nonrelevant cues are above .10 for the second block of trials due to an error in the cue values listed by McHale & Stolurow (1962).

APPENDIX G (Continued)

Group WO

| Trials | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | .01 | .03 | .68 | .29 | -.05 | .03 | .54 | .22 |
| 2 | -.01 | .17 | .07 | .78 | .18 | -.18 | .46 | .32 |
| 3 | .11 | -.22 | .39 | .44 | -.04 | .27 | .16 | .00 |
| 4 | -.03 | .23 | .35 | -.28 | -.01 | .26 | .58 | .28 |
| 5 | .14 | .62 | -.27 | -.29 | -.06 | .55 | .34 | .52 |
| 6 | .22 | .56 | .16 | .41 | .22 | .60 | .11 | .32 |
| 7 | .26 | .66 | .15 | .10 | .46 | .72 | .10 | -.10 |
| 8 | .44 | .75 | .14 | .22 | .42 | .77 | -.06 | .15 |
| 9 | .12 | .54 | .20 | -.12 | .41 | .51 | .23 | .27 |
| 10 | .05 | .71 | .14 | .28 | .31 | .89 | .04 | .09 |
| 11 | .42 | .88 | -.09 | -.02 | .52 | .80 | -.01 | -.06 |
| 12 | .36 | .92 | .02 | .02 | .36 | .57 | .08 | -.08 |
| 13 | .43 | .80 | -.18 | .02 | .22 | .78 | .24 | .20 |
| 14. | .45 | .89 | .00 | -.04 | .48 | .85 | -.02 | .02 |
| 15 | .45 | .89 | .00 | -.04 | .47 | .88 | -.03 | -.06 |
| 16 | .45 | .89 | .00 | -.04 | .35 | .86 | .05 | -.10 |
| 17 | .45 | .89 | -.08 | .21 | .44 | .89 | -.07 | .20 |
| 18 | .45 | .89 | -.08 | .21 | .47 | .84 | .02 | .10 |
| 19 | .45 | .89 | -.08 | .21 | .50 | .82 | -.19 | .19 |
| 20 | .45 | .89 | -.08 | .21 | .47 | .84 | -.11 | .31 |
| 21 | .45 | .89 | -.08 | .21 | .48 | .85 | -.06 | .24 |
| 22 | .45 | .89 | -.08 | .21 | .41 | .89 | -.12 | .24 |
| 23 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 24 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 25 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 26 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 27 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 28 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 29 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 30 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 31 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 32 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 33 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 34 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 35 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 36 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 37 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 38 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 39 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 40 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |

APPENDIX G (Continued)

Group WN

| Trial | Experiment I 1st Rel | Experiment I 2nd Rel | Experiment I 1st Irr | Experiment I 2nd Irr | Experiment II 1st Rel | Experiment II 2nd Rel | Experiment II 1st Irr | Experiment II 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | .34 | .46 | .40 | -.01 | .43 | .30 | .26 | .00 |
| 2 | .38 | .43 | .00 | -.23 | .11 | .44 | .21 | .42 |
| 3 | .20 | .22 | -.32 | .45 | .79 | .35 | -.06 | .13 |
| 4 | .50 | .77 | .08 | -.16 | .39 | .64 | .17 | .17 |
| 5 | .36 | .85 | .18 | -.09 | .45 | .74 | .02 | .02 |
| 6 | .45 | .64 | -.30 | -.06 | .50 | .44 | -.21 | .19 |
| 7 | .40 | .71 | .22 | .01 | .55 | .67 | -.04 | -.28 |
| 8 | .45 | .83 | -.01 | -.06 | .45 | .89 | .00 | -.04 |
| 9 | .50 | .85 | .02 | -.02 | .17 | .81 | .22 | .04 |
| 10 | .45 | .89 | -.03 | -.02 | .47 | .86 | .03 | -.03 |
| 11 | .50 | .73 | -.10 | .19 | .14 | .80 | .17 | .08 |
| 12 | .50 | .79 | .04 | -.01 | .39 | .88 | .00 | -.10 |
| 13 | .38 | .78 | -.09 | .02 | .25 | .87 | -.08 | -.08 |
| 14 | .40 | .92 | .00 | -.09 | .43 | .86 | -.10 | .00 |
| 15 | .40 | .88 | .08 | .04 | .50 | .86 | .00 | -.07 |
| 16 | .45 | .89 | .00 | -.04 | .39 | .90 | .06 | -.06 |
| 17 | .39 | .82 | -.02 | .16 | .38 | .89 | -.17 | .20 |
| 18 | .39 | .76 | -.23 | .45 | .40 | .91 | -.07 | .22 |
| 19 | .45 | .89 | -.08 | .21 | .49 | .79 | -.20 | .08 |
| 20 | .46 | .85 | -.02 | .21 | .37 | .88 | -.09 | .08 |
| 21 | .47 | .88 | -.17 | .23 | .42 | .72 | -.09 | .19 |
| 22 | .44 | .89 | -.12 | .24 | .39 | .90 | -.11 | .19 |
| 23 | .48 | .86 | -.01 | .26 | .52 | .82 | -.12 | .10 |
| 24 | .45 | .89 | -.08 | .21 | .35 | .61 | -.18 | .28 |
| 25 | .45 | .89 | -.08 | .21 | .19 | .67 | .20 | .31 |
| 26 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 27 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 28 | .45 | .89 | -.08 | .21 | .50 | .82 | -.19 | .19 |
| 29 | .45 | .89 | -.08 | .21 | .39 | .88 | -.05 | .10 |
| 30 | .45 | .89 | -.08 | .21 | .50 | .78 | -.04 | .26 |
| 31 | .45 | .89 | -.08 | .21 | .44 | .89 | -.12 | .24 |
| 32 | .45 | .89 | -.08 | .21 | .47 | .88 | -.05 | .24 |
| 33 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 34 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 35 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 36 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 37 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 38 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 39 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 40 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |

# APPENDIX G (Continued)

## Group XS

| Trial | Experiment I 1st Rel | Experiment I 2nd Rel | Experiment I 1st Irr | Experiment I 2nd Irr | Experiment II 1st Rel | Experiment II 2nd Rel | Experiment II 1st Irr | Experiment II 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | .21 | .52 | -.02 | .04 | .60 | .40 | -.40 | -.05 |
| 2 | -.10 | .04 | -.33 | .41 | .42 | .44 | -.30 | .24 |
| 3 | .42 | -.05 | .05 | -.49 | .39 | .47 | .43 | -.07 |
| 4 | .03 | .03 | -.20 | .41 | .46 | .24 | .10 | .15 |
| 5 | .45 | .49 | .08 | .28 | -.11 | .70 | .29 | -.02 |
| 6 | .12 | .46 | .20 | -.20 | .15 | .59 | -.08 | -.19 |
| 7 | .06 | .87 | .18 | -.08 | .37 | .60 | .32 | .06 |
| 8 | .34 | .22 | .22 | -.36 | .23 | .43 | -.33 | .50 |
| 9 | .10 | .65 | -.01 | .01 | .46 | .35 | .30 | .28 |
| 10 | .22 | .49 | .01 | -.11 | .43 | .58 | -.25 | -.08 |
| 11 | .45 | .61 | .12 | -.09 | .39 | .68 | .19 | .08 |
| 12 | .35 | .53 | -.12 | -.35 | .57 | .44 | -.23 | -.02 |
| 13 | .40 | .30 | -.16 | .34 | .39 | .55 | -.23 | .31 |
| 14 | .07 | .72 | .40 | .09 | .27 | .74 | .25 | .18 |
| 15 | .04 | .46 | -.20 | .39 | .33 | .77 | .06 | -.06 |
| 16 | .12 | .53 | .38 | -.29 | .29 | .82 | -.01 | -.07 |
| 17 | .39 | .85 | -.14 | .22 | .61 | .61 | .19 | .32 |
| 18 | .22 | .22 | .62 | .17 | .47 | .88 | -.12 | .21 |
| 19 | .30 | .89 | -.22 | .10 | .45 | .89 | -.08 | .21 |
| 20 | .38 | .82 | -.07 | .40 | .42 | .90 | -.09 | .20 |
| 21 | .61 | .68 | -.27 | .18 | .45 | .89 | -.08 | .21 |
| 22 | .45 | .89 | -.09 | .17 | .45 | .89 | -.08 | .21 |
| 23 | .47 | .77 | -.07 | .21 | .45 | .89 | -.08 | .21 |
| 24 | .61 | .63 | .16 | .36 | .45 | .89 | -.08 | .21 |
| 25 | .50 | .85 | -.09 | .22 | .45 | .89 | -.08 | .21 |
| 26 | .46 | .88 | -.09 | .25 | .45 | .89 | -.08 | .21 |
| 27 | .50 | .78 | -.04 | .26 | .45 | .89 | -.08 | .21 |
| 28 | .45 | .87 | -.01 | .16 | .45 | .89 | -.08 | .21 |
| 29 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 30 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 31 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 32 | .45 | .89 | -.08 | .21 | .45 | .89 | -.08 | .21 |
| 33 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 34 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 35 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 36 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 37 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 38 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 39 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 40 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |

# APPENDIX G (Continued)

## Group XO

| Trial | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | -.22 | .01 | .24 | .08 | .16 | -.06 | .23 | .60 |
| 2 | -.02 | .15 | .58 | -.09 | -.28 | .32 | .44 | .15 |
| 3 | .16 | .50 | .03 | -.08 | -.14 | .16 | .11 | .36 |
| 4 | .01 | .32 | .11 | -.28 | .08 | .42 | .19 | .15 |
| 5 | .47 | .44 | .19 | -.26 | .48 | .44 | .14 | .04 |
| 6 | -.03 | .62 | -.11 | -.17 | -.01 | .71 | -.15 | -.27 |
| 7 | .55 | .32 | -.35 | -.03 | .42 | .61 | -.03 | .31 |
| 8 | .11 | .32 | .11 | -.15 | .21 | .24 | -.16 | -.27 |
| 9 | -.06 | .44 | .42 | .25 | .58 | .46 | -.13 | .23 |
| 10 | .53 | .46 | .15 | .37 | -.09 | .42 | .33 | -.11 |
| 11 | .48 | .52 | -.15 | .27 | .38 | .63 | .10 | -.20 |
| 12 | .46 | .73 | .00 | -.07 | .44 | .67 | -.15 | .28 |
| 13 | .40 | .78 | -.02 | .05 | .22 | .71 | .29 | .17 |
| 14 | .09 | .54 | -.13 | -.11 | .26 | .67 | .23 | -.32 |
| 15 | .48 | .72 | .00 | .04 | .36 | .80 | -.08 | -.04 |
| 16 | .33 | .77 | -.16 | .18 | .40 | .86 | .08 | -.02 |
| 17 | .17 | .87 | -.21 | .07 | .39 | .81 | -.02 | .27 |
| 18 | .58 | .62 | -.12 | .22 | .49 | .82 | -.09 | .16 |
| 19 | .30 | .77 | -.06 | .29 | .46 | .64 | -.16 | .39 |
| 20 | .51 | .62 | .09 | .35 | .38 | .88 | .02 | .27 |
| 21 | .13 | .73 | -.08 | .34 | .36 | .73 | -.02 | .21 |
| 22 | .32 | .87 | -.14 | .17 | .52 | .82 | .03 | .24 |
| 23 | .08 | .64 | .04 | .50 | .42 | .77 | .11 | .06 |
| 24 | .28 | .67 | .01 | .29 | .45 | .89 | -.08 | .21 |
| 25 | .45 | .89 | -.09 | .22 | .53 | .78 | .06 | .24 |
| 26 | .37 | .74 | .06 | .08 | .59 | .70 | -.14 | .14 |
| 27 | .33 | .87 | -.13 | .32 | .45 | .89 | -.08 | .21 |
| 28 | .50 | .63 | -.30 | .14 | .45 | .89 | -.08 | .21 |
| 29 | .41 | .89 | -.11 | .21 | .45 | .89 | -.08 | .21 |
| 30 | .49 | .68 | .12 | .13 | .45 | .89 | -.08 | .21 |
| 31 | .43 | .82 | .07 | .09 | .45 | .89 | -.08 | .21 |
| 32 | .31 | .69 | -.08 | .03 | .45 | .89 | -.15 | .21 |
| 33 | .18 | .84 | .00 | .07 | .45 | .89 | .02 | -.07 |
| 34 | .45 | .89 | .02 | -.07 | .35 | .86 | .08 | -.12 |
| 35 | .36 | .75 | .22 | -.20 | .45 | .89 | .02 | -.07 |
| 36 | .43 | .90 | -.01 | -.06 | .45 | .89 | .02 | -.07 |
| 37 | .15 | .61 | -.29 | .03 | .45 | .89 | .02 | -.07 |
| 38 | .45 | .89 | .02 | -.07 | .45 | .89 | .02 | -.07 |
| 39 | .50 | 163 | -.20 | -.29 | .45 | .89 | .02 | -.07 |
| 40 | .31 | .92 | .08 | -.12 | .45 | .89 | .02 | -.07 |

APPENDIX G (Continued)

Group XN

| Trials | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | .20 | -.01 | -.17 | .34 | .18 | .67 | .42 | -.03 |
| 2 | -.06 | .25 | .25 | .11 | .31 | .05 | -.33 | .07 |
| 3 | -.30 | .12 | -.23 | .42 | .58 | .18 | .36 | -.06 |
| 4 | .18 | .61 | .18 | -.13 | .55 | .60 | -.09 | .07 |
| 5 | .57 | .04 | .00 | -.55 | .28 | .17 | -.20 | .40 |
| 6 | .25 | .79 | -.08 | -.04 | .50 | .10 | .26 | -.12 |
| 7 | .21 | .37 | .19 | .07 | .29 | -.12 | .19 | .10 |
| 8 | .48 | .48 | .19 | .21 | .74 | .33 | .04 | .18 |
| 9 | .14 | .68 | -.19 | .19 | .16 | .52 | -.06 | -.36 |
| 10 | .27 | .82 | .01 | .06 | -.13 | .03 | .39 | -.34 |
| 11 | .23 | .78 | -.27 | -.09 | .11 | .45 | .21 | .04 |
| 12 | .34 | .42 | .30 | .38 | .52 | .67 | -.18 | .07 |
| 13 | .40 | .75 | -.20 | -.10 | .41 | .70 | .15 | -.04 |
| 14 | .17 | .71 | -.27 | -.17 | .49 | .70 | .10 | -.21 |
| 15 | .58 | .54 | .14 | .10 | .61 | .53 | .13 | -.23 |
| 16 | .42 | .44 | .07 | -.14 | .50 | .63 | .03 | -.03 |
| 17 | .23 | .86 | .10 | .38 | .42 | .81 | .10 | .19 |
| 18 | .60 | .64 | -.19 | .18 | .46 | .70 | -.01 | .27 |
| 19 | .29 | .82 | -.05 | .46 | .45 | .87 | -.08 | .13 |
| 20 | .16 | .56 | -.24 | -.13 | .40 | .68 | .00 | .16 |
| 21 | .35 | .85 | -.17 | .16 | .22 | .92 | -.28 | .08 |
| 22 | .46 | .87 | -.02 | .23 | .45 | .78 | -.19 | .06 |
| 23 | .52 | .80 | -.08 | .07 | .14 | .61 | -.06 | .53 |
| 24 | .44 | .89 | -.07 | .20 | .25 | .71 | -.22 | .06 |
| 25 | .35 | .86 | .06 | .28 | .25 | .56 | .28 | .29 |
| 26 | .40 | .84 | -.03 | .17 | .23 | .78 | -.11 | .15 |
| 27 | .46 | .86 | -.01 | .14 | .55 | .79 | -.12 | .06 |
| 28 | .42 | .90 | -.05 | .22 | .52 | .64 | -.33 | .28 |
| 29 | .37 | .86 | -.04 | .07 | .46 | .57 | .08 | .36 |
| 30 | .45 | .89 | -.08 | .21 | .43 | .62 | .17 | .09 |
| 31 | .35 | .61 | .21 | -.04 | .34 | .62 | .17 | -.01 |
| 32 | .20 | .77 | -.30 | -.01 | .52 | .67 | -.17 | .12 |
| 33 | .26 | .87 | -.03 | .09 | -.20 | .52 | .12 | .18 |
| 34 | .45 | .89 | .02 | -.07 | .39 | .87 | -.01 | .06 |
| 35 | .45 | .89 | .02 | -.07 | .45 | .88 | .01 | -.09 |
| 36 | .45 | .89 | .02 | -.07 | .27 | .60 | .31 | -.13 |
| 37 | .45 | .89 | .02 | -.07 | .35 | .64 | .00 | .13 |
| 38 | .50 | .78 | .07 | -.02 | .42 | .90 | .01 | -.08 |
| 39 | .38 | .92 | .08 | -.06 | .64 | .58 | -.27 | -.03 |
| 40 | .60 | .64 | -.17 | .12 | .34 | .87 | .19 | -.23 |

APPENDIX G (Continued)

Control Groups

| Trial | Experiment I 1st Rel | Experiment I 2nd Rel | Experiment I 1st Irr | Experiment I 2nd Irr | Experiment II 1st Rel | Experiment II 2nd Rel | Experiment II 1st Irr | Experiment II 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | -.12 | .56 | .38 | -.09 | .40 | .70 | .15 | -.11 |
| 2 | .34 | -.13 | .15 | -.38 | .30 | .34 | -.34 | .03 |
| 3 | .37 | .03 | -.18 | .09 | .30 | -.16 | -.30 | .12 |
| 4 | .22 | .13 | .62 | .53 | .73 | .27 | .12 | .09 |
| 5 | -.24 | .02 | .62 | .00 | -.35 | .33 | .16 | .20 |
| 6 | .44 | .21 | -.02 | -.10 | .32 | .18 | .04 | .25 |
| 7 | .62 | -.32 | -.16 | -.03 | .60 | .18 | -.07 | .16 |
| 8 | .53 | -.22 | -.04 | .01 | .27 | -.23 | .27 | .02 |
| 9 | .07 | .02 | .55 | .43 | .00 | -.06 | .28 | .15 |
| 10 | .10 | .70 | .34 | .08 | .46 | .13 | .08 | .26 |
| 11 | .08 | .11 | -.21 | .25 | .28 | .36 | .18 | -.03 |
| 12 | .27 | .07 | .53 | .49 | -.03 | .71 | -.07 | -.10 |
| 13 | .26 | .16 | -.26 | .22 | .15 | .62 | .13 | -.04 |
| 14 | -.03 | .04 | .14 | .1[illegible] | .47 | .65 | .19 | .14 |
| 15 | .24 | -.29 | .21 | -.11 | .72 | .14 | .30 | -.18 |
| 16 | -.19 | .58 | .39 | -.06 | .05 | .47 | .09 | .24 |
| 17 | .10 | .52 | -.13 | .12 | .57 | .57 | .08 | -.09 |
| 18 | .08 | -.07 | .43 | .02 | .12 | .83 | -.18 | .38 |
| 19 | .41 | .47 | -.04 | .43 | .39 | .45 | .17 | .55 |
| 20 | .52 | .52 | .01 | .18 | .02 | .20 | -.23 | -.01 |
| 21 | .49 | .13 | -.08 | -.10 | .44 | .55 | .11 | .47 |
| 22 | .31 | .35 | -.02 | .53 | .37 | .68 | .04 | .27 |
| 23 | .29 | .70 | -.03 | -.12 | .14 | .28 | .22 | .54 |
| 24 | .52 | .43 | -.08 | .24 | .18 | .65 | -.01 | .22 |
| 25 | .19 | .46 | .29 | .14 | .36 | .57 | .27 | .11 |
| 26 | .24 | .70 | .08 | .36 | .44 | .67 | .07 | -.08 |
| 27 | .44 | .70 | -.08 | .29 | 9 | .83 | -.27 | .17 |
| 28 | -.26 | .70 | -.08 | .17 | .44 | .47 | -.23 | .20 |
| 29 | .62 | .51 | .15 | .35 | .14 | .54 | .18 | -.06 |
| 30 | .32 | .75 | -.22 | .37 | .28 | .72 | -.11 | .34 |
| 31 | .69 | .34 | .04 | .42 | .33 | .86 | -.21 | .23 |
| 32 | .14 | .75 | -.17 | .45 | .33 | .76 | .14 | .34 |
| 33 | .58 | .71 | -.07 | -.04 | .43 | .90 | .03 | -.08 |
| 34 | .28 | .82 | -.21 | .08 | .41 | .67 | .06 | .17 |
| 35 | .44 | .72 | -.01 | .18 | .22 | .72 | .07 | -.05 |
| 36 | .29 | .71 | -.32 | -.06 | .13 | .60 | -.03 | .13 |
| 37 | .39 | .75 | .14 | .18 | .44 | .70 | .05 | .00 |
| 38 | .14 | .77 | -.03 | .11 | .34 | .90 | .11 | -.05 |
| 39 | .43 | .61 | .25 | -.06 | .57 | .63 | -.14 | .01 |
| 40 | .17 | .24 | .46 | .24 | .38 | .79 | .00 | .04 |

## APPENDIX H

### Average Relevant and Irrelevant Cue Criterialities for Overlapping Trials on the Criterion Task (Figures 7, 8, and 9)

| Blocks of Trials | Same Cue Groups | | Opposite Cue Groups | | New Cue Groups | |
|---|---|---|---|---|---|---|
| | Relevant | Irrelevant | Relevant | Irrelevant | Relevant | Irrelevant |
| 1-2 | 34.00 | 19.44 | 11.75 | 35.06 | 28.88 | 20.03 |
| 2-3 | 35.88 | 22.94 | 18.19 | 27.88 | 29.81 | 22.81 |
| 3-4 | 36.94 | 20.00 | 18.50 | 23.69 | 43.62 | 18.31 |
| 4-5 | 39.25 | 17.75 | 28.50 | 26.88 | 48.12 | 15.69 |
| 5-6 | 42.44 | 16.69 | 38.56 | 19.31 | 46.44 | 17.00 |
| 6-7 | 43.25 | 14.94 | 43.56 | 17.94 | 44.12 | 14.75 |
| 7-8 | 48.12 | 18.44 | 45.38 | 15.19 | 49.81 | 11.69 |

# APPENDIX I

## Single S Criterialities--Block 1

### Group WS

| S# | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 1 | .77 | .30 | .01 | .20 | .45 | .30 | -.19 | .50 |
| 8 | .49 | .80 | .09 | -.04 | .36 | .90 | .04 | -.18 |
| 15 | .45 | .89 | .00 | -.04 | .45 | .89 | .03 | -.08 |
| 22 | -.04 | .10 | -.13 | .37 | .50 | .68 | -.30 | .01 |
| 29 | .34 | .77 | .08 | .04 | .09 | .15 | .18 | .67 |
| 36 | .39 | .74 | -.17 | .03 | .41 | .82 | -.07 | -.15 |
| 43 | -.10 | .62 | -.03 | .08 | .42 | .88 | .01 | -.04 |
| 50 | .45 | .89 | .00 | -.04 | .62 | .30 | .20 | -.28 |
| 57 | .47 | .86 | -.02 | .02 | .31 | .74 | .24 | .07 |
| 64 | .45 | .89 | .00 | -.04 | .54 | .50 | -.02 | .38 |
| 71 | .48 | .78 | -.02 | -.02 | .30 | .76 | .06 | .28 |
| 78 | .24 | .83 | -.14 | -.12 | .45 | .89 | .00 | -.04 |
| 85 | .70 | .21 | .27 | -.25 | .51 | .62 | -.25 | -.12 |
| 92 | .25 | .55 | -.03 | .17 | .45 | .89 | .00 | -.04 |
| 99 | .21 | .76 | .27 | .11 | .40 | .91 | -.01 | -.08 |
| 106 | .60 | .76 | .00 | .10 | .29 | .58 | .42 | -.08 |

APPENDIX I (Continued)

Group WO

| S# | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 2 | .37 | .63 | .11 | -.20 | .42 | .60 | .23 | -.17 |
| 9 | .45 | .89 | .00 | -.04 | .36 | .90 | .04 | -.18 |
| 16 | .34 | .20 | -.09 | .26 | .35 | .79 | .25 | -.30 |
| 23 | .27 | .21 | -.45 | -.05 | .16 | .16 | -.06 | .57 |
| 30 | .52 | .54 | -.06 | .11 | .23 | .47 | .28 | .28 |
| 37 | .23 | .59 | .18 | .01 | .12 | .27 | .17 | -.15 |
| 44 | -.22 | .54 | .58 | .24 | .05 | .64 | .43 | .02 |
| 51 | -.11 | .54 | .24 | .34 | .20 | -.20 | .68 | .39 |
| 58 | .22 | .57 | .22 | .18 | .11 | .70 | .27 | -.01 |
| 65 | .47 | .84 | -.09 | .05 | .39 | .52 | .17 | .60 |
| 72 | .35 | .50 | .33 | .33 | .20 | .74 | .14 | .29 |
| 79 | .45 | .89 | .00 | -.04 | .28 | .68 | .37 | .18 |
| 86 | .39 | .90 | .05 | .01 | .36 | .53 | .10 | .12 |
| 93 | .09 | .76 | .11 | .35 | .30 | .66 | -.08 | .19 |
| 100 | .21 | .76 | .27 | .11 | .32 | .63 | .28 | .19 |
| 107 | .01 | .09 | .41 | .07 | .27 | .86 | .10 | .12 |

APPENDIX I (Continued)

Group WN

| S# | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 3 | .37 | .61 | -.13 | -.24 | .47 | .81 | .04 | -.08 |
| 10 | .23 | .40 | .02 | -.25 | .53 | .83 | -.01 | .04 |
| 17 | .60 | .65 | .00 | -.02 | .55 | .70 | -.05 | .00 |
| 24 | .44 | .89 | .03 | -.05 | .48 | .85 | .01 | .01 |
| 31 | .30 | .46 | -.22 | .00 | .45 | .89 | .00 | -.04 |
| 38 | .41 | .89 | .02 | -.07 | .23 | .54 | .26 | .00 |
| 45 | .35 | .86 | .05 | -.10 | .46 | .88 | -.01 | -.01 |
| 52 | .52 | .56 | .00 | .05 | .47 | .33 | .27 | -.10 |
| 59 | .25 | .78 | .20 | .05 | .42 | .88 | .06 | .01 |
| 66 | .37 | .63 | .09 | .37 | .41 | .79 | -.11 | .11 |
| 73 | .50 | .85 | .02 | -.02 | .45 | .89 | .00 | -.04 |
| 80 | .40 | .88 | .08 | .04 | .60 | .71 | .05 | -.16 |
| 87 | .42 | .79 | -.02 | .10 | .34 | .92 | .05 | .05 |
| 94 | .40 | .84 | -.13 | .09 | .52 | .56 | -.24 | -.04 |
| 101 | .45 | .89 | .03 | -.08 | -.37 | .27 | .15 | -.07 |
| 108 | .56 | .63 | .10 | .01 | .39 | .39 | .12 | .47 |

## APPENDIX I (Continued)

Group XS

| S# | Experiment I 1st Rel | Experiment I 2nd Rel | Experiment I 1st Irr | Experiment I 2nd Irr | Experiment II 1st Rel | Experiment II 2nd Rel | Experiment II 1st Irr | Experiment II 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 4 | .09 | -.06 | .06 | .25 | .47 | .72 | -.12 | -.02 |
| 11 | .16 | .34 | .50 | .07 | .33 | .90 | .06 | -.18 |
| 18 | .11 | .06 | -.13 | .20 | .34 | .19 | -.22 | .12 |
| 25 | -.49 | -.10 | .30 | .21 | .49 | .85 | -.06 | .04 |
| 32 | .26 | .54 | .01 | -.01 | .38 | .38 | -.05 | -.03 |
| 39 | .06 | .18 | -.15 | .00 | .48 | .78 | -.12 | -.12 |
| 46 | .23 | .72 | .08 | -.14 | .32 | .89 | -.02 | -.14 |
| 53 | .53 | .82 | .08 | -.02 | .26 | .72 | -.01 | .41 |
| 60 | .54 | .69 | .16 | -.10 | .27 | -.02 | -.05 | .36 |
| 67 | -.07 | .07 | -.07 | -.73 | .49 | .59 | .04 | .41 |
| 74 | .42 | .79 | -.10 | .05 | .45 | .89 | .03 | -.08 |
| 81 | .08 | .00 | .15 | -.02 | .29 | .75 | .10 | -.03 |
| 88 | .32 | .62 | -.15 | .18 | .12 | .21 | .23 | .05 |
| 95 | .27 | .86 | -.09 | .17 | .13 | .20 | .20 | .02 |
| 102 | .53 | .39 | -.13 | .31 | .51 | .19 | .21 | .27 |
| 109 | .37 | .84 | -.08 | -.12 | 48 | .86 | -.06 | -.10 |

APPENDIX I (Continued)

Group XO

| | Experiment I | | | | Experiment II | | | |
|---|---|---|---|---|---|---|---|---|
| S# | 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
| 5 | -.30 | .10 | -.36 | -.23 | .34 | .76 | .03 | -.17 |
| 12 | .16 | .22 | .40 | -.43 | .36 | .79 | .00 | .07 |
| 19 | .44 | .56 | .08 | -.13 | .47 | .71 | -.12 | -.15 |
| 26 | .44 | .89 | .03 | -.05 | -.04 | .26 | -.44 | .00 |
| 33 | .48 | .85 | -.02 | .02 | .19 | .60 | .14 | .15 |
| 40 | .15 | .47 | .35 | -.15 | -.17 | .12 | .48 | -.19 |
| 47 | -.07 | .58 | .12 | .12 | .07 | -.31 | -.29 | .24 |
| 54 | .23 | .18 | .28 | .14 | .38 | .47 | .13 | .46 |
| 61 | .46 | .34 | .00 | .41 | .41 | .89 | .07 | -.02 |
| 68 | .38 | .46 | .06 | .06 | .11 | -.07 | .29 | .21 |
| 75 | .45 | .89 | .00 | -.04 | .39 | .81 | -.05 | .17 |
| 82 | .21 | .62 | -.11 | .05 | .45 | .89 | .03 | -.08 |
| 89 | .49 | .81 | -.12 | -.01 | .36 | .92 | .02 | .02 |
| 96 | .32 | .92 | .03 | .05 | .24 | .58 | .35 | .19 |
| 103 | -.13 | .15 | .36 | -.17 | .12 | .66 | .10 | .31 |
| 110 | .00 | .32 | .06 | .19 | -.30 | .12 | .66 | -.16 |

APPENDIX I (Continued)

Group XN

| S# | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 6 | .53 | .76 | -.01 | -.01 | .27 | -.11 | .14 | -.30 |
| 13 | .22 | -.08 | -.35 | -.03 | .45 | .70 | .12 | -.16 |
| 20 | .46 | .87 | -.08 | .03 | .52 | .69 | -.02 | .07 |
| 27 | .45 | .89 | -.03 | -.03 | .45 | .87 | -.07 | -.02 |
| 34 | .11 | .26 | .09 | .16 | .41 | .84 | -.06 | -.19 |
| 41 | .26 | .70 | .21 | .01 | .30 | .51 | .04 | -.02 |
| 48 | .59 | -.01 | .01 | .53 | .45 | .89 | .00 | -.04 |
| 55 | .12 | .56 | .08 | .33 | .40 | .84 | .12 | .09 |
| 62 | .37 | .84 | -.10 | .12 | .39 | .77 | .07 | .05 |
| 69 | -.22 | .11 | -.16 | -.10 | .19 | .37 | .48 | .06 |
| 76 | .48 | .72 | -.03 | .08 | .01 | -.34 | -.42 | .29 |
| 83 | .45 | .89 | .00 | -.04 | .34 | .85 | -.07 | .15 |
| 90 | .35 | .68 | -.18 | -.32 | .60 | .34 | .30 | -.38 |
| 97 | .18 | .12 | .43 | .01 | .40 | -.16 | -.25 | .08 |
| 104 | -.10 | .12 | .05 | -.01 | .30 | -.39 | .50 | .06 |
| 111 | .20 | .77 | .22 | .18 | .32 | -.11 | .30 | -.13 |

APPENDIX I (Continued)

Control Group

| S# | Experiment I 1st Rel | 2nd Rel | 1st Irr | 2nd Irr | Experiment II 1st Rel | 2nd Rel | 1st Irr | 2nd Irr |
|---|---|---|---|---|---|---|---|---|
| 7 | -.68 | -.03 | .14 | -.08 | -.01 | .74 | .15 | .21 |
| 14 | -.34 | .05 | .03 | -.03 | .08 | .42 | .14 | .20 |
| 21 | .33 | .43 | .31 | -.28 | .25 | .27 | -.11 | .25 |
| 28 | .71 | .38 | .16 | .24 | .51 | .23 | -.13 | .38 |
| 35 | .07 | .02 | .46 | .10 | .03 | -.01 | .22 | -.38 |
| 42 | .20 | .22 | .60 | .02 | .45 | .89 | .00 | -.04 |
| 49 | .48 | .30 | .50 | .21 | -.04 | .67 | .18 | -.41 |
| 56 | .30 | -.16 | .43 | .41 | -.08 | -.08 | -.32 | .20 |
| 65 | .10 | .33 | .06 | -.10 | .47 | .37 | -.12 | .44 |
| 70 | .35 | -.38 | -.43 | .08 | .70 | .48 | .30 | -.04 |
| 77 | .30 | .78 | .03 | .08 | .12 | .29 | .07 | -.05 |
| 84 | .04 | -.26 | .53 | .24 | .46 | -.35 | .09 | .19 |
| 91 | .15 | .52 | -.17 | .21 | .66 | .38 | .14 | .32 |
| 98 | .55 | .25 | .16 | .39 | .56 | .57 | .25 | -.09 |
| 105 | .30 | -.32 | .40 | .05 | .28 | -.10 | .44 | -.25 |
| 112 | .00 | -.10 | .08 | .02 | .44 | .12 | .01 | .12 |

# VITA

Dale Edward Mattson was born on April 5, 1934 in Newberry, Michigan. He received his elementary and secondary education in Newberry, Michigan. He graduated from North Park Junior College in 1957 and received his Bachelor of Arts from Colorado College in 1959.

In the fall of 1960, he entered the University of Illinois as a graduate student in the College of Education; he held an N.D.E.A. fellowship in a special program in the Psychology of Classroom Learning.

He received a Master of Arts degree in June, 1961, and the Doctor of Philosophy degree in October, 1963.